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CHINA REPORT
SCIENCE AND TECHNOLOGY

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PEOPLE'S REPUBLIC OF CHINA

NATIONAL DEVELOPMENTS

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NATIONAL DEVELOPMENTS

EFFORTS TO ACCELERATE TECHNOLOGICAL TRANSFORMATION VIEWED

Beijing LIAOWANG [OUTLOOK] in Chinese 10 Mar 86 pp 14-15

[Article by Li Shiyi [2621 0013 5030]: "China Will Speed Up Technological Transformation of the National Economy--3,000 Technological Items Will Be Imported in the Next 5 Years"]

[Text] In the past 5 years, China spent the huge sum of 140 billion yuan on technical transformation of enterprises. In the last 3 years, China imported 3,000 advanced technological items from abroad to replace obsolete technology and equipment.

This shows that China no longer follows the extensive economic development road by simply launching new projects. Instead, China is turning its attention to the technical improvement of the existing enterprises, embarking on the road of intensive economic development.

The practice has shown great results. In the past 5 years, China's investment for the first time increased at a faster rate in technical transformation than in capital construction; 200,000 technical transformation projects were expected to be completed and put into production, of which more than 500 cost more than 10 million yuan each; and fixed assets increased by 110 billion yuan, equivalent to one-fifth of the original cost of the fixed assets of all state-owned enterprises in China in 1980. Thus it can be seen that seeking technolological progress has become the new trend of economic construction in this country.

Imports of Advanced Foreign Technology Will Continue.

China began to open its doors to welcome advanced and suitable technology from abroad 7 years ago after Chairman Deng Xiaoping put forward the policy of enlivening the domestic economy and opening to the outside world. Three years ago, the state began an experiment in Shanghai, Tianjin, Dalian, Qingdao, Chongqing and other cities, giving them a suitable amount of power to import advanced technology from abroad. Later on, a series of encouraging policies were formulated to transfer to lower levels the power to examine and approve technology imports and simplify examination and approval procedures. Since the opening of 14 coastal cities to the outside world, work in this area has been developing in full scale. Thus, in the past 3 years, in addition to the

3,000 technological items imported by the state, the localities and departments have also imported 11,000 items.

As China lacks experience in importing advanced technology from abroad, it started with prudence. It imports mainly single technologies and key equipment aimed at speeding up the technical transformation of small and medium-sized enterprises. Small and medium-sized enterprises constitute the overwhelming majority of China's industries. Their technology and equipment are obsolete and backward, and the emphasis is on importing advanced and suitable technology and equipment. For example, China's machine-building industries have imported more than 500 technologies, which can bring more than 5,000 products up to the international standards of the 1970's and the 1980's. China has also imported technologies in the fields of food, packaging, household electrical appliances, plastic products, new materials and so forth to enhance its ability to develop new products.

Between 1983 and 1985, China spent more than $10 billion to buy advanced and suitable technologies from abroad. These technologies, mastered, applied and further developed, have completely changed the technological outlook of a number of small and medium-sized enterprises in China. Tianjin Municipality imported more than 400 technological items at a cost of $400 million and developed a number of superior products, and the foreign exchange spent on the imports can be earned back within 2 years. Tianjin's woolen textile industry spent $17.59 million on technological imports, which will increase export woolen goods by 3.9 million meters and earn $34.8 million a year. China's technological imports are aimed at increasing "self-reliance," and not abandoning it.

In the next 5 years, China plans to import 3,000 advanced technological items from abroad to equip its large and medium-sized enterprises and enterprises which are able to compete in the international market. The imports will include: software technology and key equipment; production technologies and techniques for raw and semifinished materials, basic parts and components; new technologies for the manufacture of light industrial, textile, mechanical and electrical products; and technologies and equipment for quality inspection, quality control, standard measurements, testing and so forth. For this purpose, China will, in addition to raising its own foreign exchange, accept international loans and promote cooperation with foreign countries in production, designing, research and development. This will no doubt provide new opportunities for international consortiums and businessmen to enter into cooperation with China.

Strategic Shift in Construction Policy

Technological imports are only a part of China's effort toward technological transformation of the national economy. China has the ability to develop new technologies and produce new equipment and has done so.

China is trying to readjust its production structure and product mix through technological progress. In the past, China put the stress on developing heavy industry to equip the other sectors of the economy, and light industry was overlooked. The production structure became preponderantly heavy industrial.

In the past few years, China has vigorously stepped up production of light industrial and textile products which are in short supply to meet the demands of its large population and increase exports. Beginning in 1980, the state has provided 2 billion yuan each year as special loans for technological progress of the light and textile industries and the electronics industry making civilian products. In the first 4 years, these industries produced nearly 4 million washing machines, more than 400,000 refrigerators, enough black-and-white television sets to meet market demands and a greatly increased number of color television sets. Before this period, these household electrical appliances were not in production. During the same period, China increased its bicycle production by 200 percent, sewing machines by nearly 100 percent, wrist watches by 160 percent and beer by 450 percent. China's light industry grew at an annual rate of 10.5 percent, as compared with heavy industry's annual growth rate of 7.7 percent, during this period. By 1984, the ratio between light and heavy industries was readjusted to 49.9 to 50.1 from 46.9 to 53.1 four years ago. This light and heavy industrial structure is more suited to China's conditions. The brisk consumer goods market has brought real benefit to the people.

China has 550 technological transformation projects in progress for the machine building and electronics industries. It is estimated that the projects will be basically completed by the end of this year. They will add more than 4,000 new products to the machine-building industry; bring three-tenths of the products of the electronics industry up to the international standards of the 1970's and 1980's; begin serial production of 200,000-kilowatt and 300,000-kilowatt generating units and trial production of 600,000-kilowatt generating units; and begin building technologically complex ships of the 60,000-ton and 100,000-ton classes and offshore oil exploitation equipment.

Through technological transformation, China has increased the production capacity of pyrites, sulfuric acid, caustic soda, soda ash, synthetic ammonia, agricultural chemicals and fine chemical industrial products by over 4 million tons, increased cement production capacity by 40 million tons, increased glass production capacity by 3.5 million standard cases, and acquired a combined wood processing capacity to turn out nearly 400,000 cubic meters of fiberboards, plywood and shaving boards per year.

Through technological transformation, China has improved its communications, transportation, postal and telecommunications services. In the past 5 years, China added to its railway system more than 2,000 locomotives, more than 4,000 passenger cars and nearly 500,000 freight cars; increased the capacity to haul coal from Shanxi by 30 million tons; increased the cargo-handling capacity of its harbors by 13 million tons; replaced more than 80,000 trucks; increased its shipping capacity by over 1.3 million tons; and installed more than 600,000 automatic urban telephone exchanges, added more than 6,000 long distance telephone lines and initially achieved the goal of direct dialing for long distance calls among more than 20 provincial capitals.

In promoting technological transformation, China has also increased its steel production capacity by 12 million tons, and coal production capacity by more than 36 million tons.

It should be said that China has won the first battle in striving for technological progress. Although it will take time to change basically the obsolete equipment and backward technology of several hundred thousand small and medium-sized enterprises, China has already come to see that merely relying on the state to provide the money for expanding the scale of capital construction is not a less costly and more efficient way to build up the country.

In the past few years, after the reforms in China's economic system, the provinces, municipalities, autonomous regions and enterprises have been given the power to act according to the actual conditions and the right to benefit from what they accomplish. They are no longer indifferent to technological progress, but are enthusiastic about it. China has also given permission for the scientific research units to market research achievements as commodities. Thus a domestic technological supply and demand mechanism has been formed. Last autumn the CPC national conference discussed economic development policies and came up with a new thinking: "We must shift the emphasis of development to the technological transformation, renovation and expansion of existing enterprises, and have them expand reproduction chiefly by intensive means." This indicates that from now on China will make vigorous efforts to achieve the technological transformation of its economy.

It is disclosed by departments concerned that in the next 5 years China will open up a path for technological progress in the following areas: To put the emphasis on the technological transformation of large and medium-sized enterprises in order to update their products; to renovate a number of machine building, electrical, light, textile, medical and pharmaceutical and chemical industrial enterprises to make their products competitive on the international market; to continue to bring in technological imports and foreign capital; and to support the technological transformation of enterprises producing accessories, components, and basic parts.

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NATIONAL DEVELOPMENTS

ACADEMY OF SCIENCES OPENS UP INSTITUTES, LABORATORIES

Beijing LIAOWANG [OUTLOOK] in Chinese 17 Mar 86 pp 36-38

[Article by Yi Miao [2496 2641]: "Opening Up in Order To Develop Faster--a Major Reform of the Chinese Academy of Sciences"]

[Text] The Chinese Academy of Sciences has finally opened its doors. A number of its research institutes and laboratories in the frontiers of science and in fields with broad application potentials are being opened to the whole country in a planned way and to foreign countries if conditions exist.

A special scientific research institution owned by the state, the Chinese Academy of Sciences has some advanced instruments and equipment which are first-rate by national or world standards. In the past, owing to the closed state of the scientific research system caused by "departmental ownership and barriers between higher and lower levels and between different departments and regions," scientists outside of the Academy of Sciences system dared not and could not ask to use the advanced equipment. As a result, neither men nor material were put to the best possible use. Now the academy has opened up its laboratories to allow the country's outstanding scientists to make full use of the research facilities, thus providing favorable conditions for them to carry out sophisticated research work. There is every reason to believe that this measure will add new vigor to China's development in science and technology.

Requirements of the Reform Era

In the present stage of China's development, it is urgently necessary for scientific research to be geared to the needs of the national economy and serve economic construction. It is necessary to organize research geared to development needs and proceeding from actual conditions and translate scientific achievements into productive forces at a faster pace. However, this does not mean that long-range scientific research, that is, basic research which will have a bearing on national economic construction in the 1990's, can be ignored.

In the past decades, basic research has resulted in opening up many applied fields and new industries. But, in the words of Zhou Guangzhao, a physicist and vice president of the Chinese Academy of Sciences, "if basic research is to make contributions to society, it must be open, and most of the people

involved must be on the move. At the same time, to develop basic science, there must be better, broader and freer discussions and interchanges among scientists and stronger contention and cooperation between different branches of learning and academic views." The opening up of the laboratories and research institutes has created new environments and conditions for just this kind of interchanges in talents and academic views. It will enable basic research work to forge ahead with greater vitality. This is of great significance to the sustained high-speed development of medium- and long-range projects and scientific work as a whole.

The first units to be opened up are the mathematics and theoretical physics institutes and the solid atomic phase, reproductive physiology, engineering geology and 14 other laboratories. All these institutes and laboratories meet the basic conditions for opening: They have some fairly good research facilities, accumulated some materials in their fields of studies and laid the foundation for extensive exchanges with foreign countries. The Theoretical Physics Institute, established in 1978, has a research staff of less than 30 people at present, but it maintains frequent academic exchanges with more than 40 theoretical physics research units around the world and receives dozens of visiting foreign scholars each year, while maintaining cooperation and exchange relations with many domestic units or providing training for them. The scope of research here almost covers every aspect of theoretical physics, and on many research projects the institute is in direct contact or competition with institutions in the same field abroad. The ion beam technology is a new and highly applicable field of research, and one of the first units in China to study this technology is the Shanghai Metallurgy Institute, which has achieved rather important results and accumulated considerable experience in such areas as ion injection, ion beam surface analysis, ion beam processing and so forth. Of course, the most important factor is that these opened institutes and laboratories do have some highly qualified academic leaders.

The opened laboratories are relatively independent in their operations with the power to make their own decisions on launching research and other academic activities. Research projects receive financial aid from a fund. Scientists may apply for aid for research projects inluded in the subjects guide of the open laboratories, or join in cooperative research projects. They may also request financial aid to work on their own projects, provided the projects belong to the forefront or high-priority areas of scientific development and are with specific data and special features. When their applications are discussed and approved by the academic committee of the open laboratories, the scientists will receive partial or full financial assistance. The academic committee is composed of highly qualified scientists in the same fields both inside and outside the research institutes (mostly outside). In addition to making decisions on the laboratories' research orientation, appraising research projects and approving financial grants, the committee also evaluates results of research projects. The scientists can carry out research according to their own plans without interference by the institutes and laboratories. The Chinese Academy of Sciences will organize experts concerned to conduct periodical examination and evaluation of the work of the open institutes and laboratories.

Most Urgent Task Is To Train a Large Number of Senior Research Personnel

Owing to special historical reasons, the number of outstanding high-level scientific and technological workers in the 30-45 age bracket is far too small in China today. In some fields, there is a shortage of personnel and a lack of successors. Scientists of the older generation point out that the most urgent task today is to train a number of high-level young scientists and technicians as quickly as possible and create a better research environment and other needed conditions for them.

The meaning of a scientist's life lies in achievements. Because of this, the scientific research environment is an extremely important and in a certain sense decisive factor. The scientists who came forward in the 1950's are now mostly in their sixties and do not have many more working years left. Yet in the little time they still have, these people are often painfully forced to waste a lot of their energy on such trivial matters as raising funds for experiments and research, purchasing needed equipment and so forth. In numerous cases, when teachers help their students in choosing a subject, their choice is limited by the equipment available. The work environment and experimental facilities are no doubt very important to old, middle-aged and young scientists.

Objectively speaking, China is rather far behind advanced levels abroad in experimental equipment and conditions as a whole, but this is not always true everywhere and in every case. We do have quite a number of laboratories which are up to advanced standards. Only because of the defects of a closed scientific research system under departmental ownerships and with barriers between higher and lower levels and between different departments and regions, it is difficult for people to move from one institution to another and all but impossible for equipment belonging to one unit to be used by others. The doors of a few research institutes and laboratories are always shut tight, and their high-class instruments and equipment are closely guarded and rarely used, while researchers elsewhere, including the very best, are barred from using them.

There is no shortage of talents nor "Boles" on the land of China. There are many unreclaimed "virgin lands" and many ambitious developers. While there are the "Boles," "winged steeds" must also be chosen. What reason is there not to provide the conditions for them to gallop about on their own vast land? It is about time to put an end to the abnormal state of departmental ownership and each unit doing things in its own way. We should let the country's most outstanding and talented young and middle-aged scientists and technicians take their most valuable research projects into the most sophisticated laboratories and let them have the sound research environment and conditions to produce first-class results.

At present, tens of thousands of Chinese scholars are pursuing advanced studies abroad. Many of them are successful young scientists. Some still remember how tightly laboratories in China were closed in the past and worry that they will not have the necessary working conditions when they return. The opening up of the laboratories perhaps can relieve them of their worry. Laboratories and equipment have opened up, and the question is whether you

have the ability and qualifications to gain entrance to the laboratories through competition.

It is believed that through nationwide competition, China's most advanced equipment will be made available to the best qualified to carry out the most valuable scientific research projects. This surely will also give an impetus to the training of outstanding young talents.

China Needs This Completely New Experiment Base

The participation of outstanding foreign scientists in research is often regarded by the open laboratories in many countries as an indication of their high standard and vitality, because it indicates a lively academic atmosphere and active academic thoughts and because it shows that scientists can achieve results within a short period there. China has made a good beginning in opening up laboratories. A first group of several dozen foreign scholars have already been attracted to work here. They are attracted by the distinctive features of the Chinese laboratories and the research projects, some of which are unique and can be done only in China. They firmly believe that exploratory and sophisticated research is being carried out here.

As a rule, the open laboratories keep only a few regular research personnel, less than one-third of the staff, and the other two-thirds are temporary personnel changing from time to time. This arrangement insures broadness of research and academic democracy. The academic committee of the Structural Analysis Laboratory, an open laboratory at the China University of Science and Technology is composed largely of experts and professors from outside the university, in the fields of physics, chemistry, biology, earth science, medical science and so forth, and only one-fourth of the committee members are from the university itself. The research projects sponsored by the laboratory have attracted a number of guest or visiting researchers who are mainly doing postgraduate or postdoctoral work. These people are highly mobile. They may work here for a few weeks, a few months, or even longer.

The ability to attract outstanding Chinese and foreign scholars to work in the open laboratories has made it possible to pool the expertise of many talented people. The laboratories constantly see people leaving with results of their research and people coming in with their research projects, bringing with them new viewpoints, new ideas and new directions of research. All this is conducive to promoting wide exchanges of academic ideas and talents and to creating a kind of soil and temperature for outstanding scientists and technicians to develop. At the same time, it is also conducive to the crossing and blending of different branches of science, accelerating the development of new sciences and pushing forward China's scientific research work on a broader scale. The opening up of laboratories has no doubt provided a completely new experimental base for China's scientific and technological work, and on this base China's science and technology is gaining new vigor.

Let People Remember the Word "Results"

China is engaged in all-round construction. On the one hand, with limited economic resources, it is impossible to equip a large number of research

laboratories at the same time, and investment can only be made selectively in some of them to upgrade their key equipment. On the other hand, science and technology are developing rapidly in the present era, and new ideas, new sciences and their frontier branches are being developed almost daily. Many high-grade, precision and advanced research projects require a whole set of high-grade, precision and advanced instruments, equipment and laboratories. A lot of money is needed to set up this kind of laboratories and to maintain them. According to some experts, it takes 2 or 3 years, if all goes well, to build a laboratory capable of handling relatively complex and large-scale experiments. It is clearly unrealistic to develop science and technology by building a large number of high-grade laboratories.

Therefore, it has become an urgent task to make the best possible use of the existing laboratories and equipment. Opening up of laboratories is a good way to achieve that. The Structural Analysis Laboratory at the China University of Science and Technology is a comprehensive analytical research center with a considerable number of advanced instruments and equipment. However, after the laboratory was put into operation, many of the sophisticated instruments and equipment were used only a few times each year. Since it became an open laboratory, it has had a packed schedule all year round, operating 24 hours everyday.

In fact, the need for open laboratories is critical in some fields of research. Some important subjects, which have already produced impressive results in developed countries, are making slow progress in China. For example, research in fungi began in the early 18th century. People have come to understand now the inseparably close relationship between fungi and human life, and a great deal of work is done in fungi research in many countries. In China, however, fungi research is still an underdeveloped field. The fungi laboratory at the Microbiology Institute of the Chinese Academy of Sciences is the only fungi research center in China with a good staff and notable achievements. Its excellent seed fungi stock is the only one of its kind in Asia outside of Japan. If closed to outsiders, the laboratory's potential can hardly be tapped, and enthusiasm cannot be aroused. The laboratory would only drag itself along at a slow pace, and promoting nationwide development of research in this field would be out of the question. Now the laboratory staff can finally heave a sigh of relief: Opening itself up will bring a twofold benefit--internally to enliven research in this field at home, and externally to draw from experience abroad and attain a higher academic level.

Moreover, to better serve economic construction, scientific research must also be closely combined with education and production. The opening up of the laboratories has provided channels for exchange and cooperation between the Academy of Sciences and the universities and colleges and production departments, making it possible for faster popularization and practical application of scientific achievements. There are nearly 400,000 teaching and research personnel in China's institutions of higher education. Among them the associate professors and those in higher positions account for about one-half of the country's senior technical force. About one-half of China's postgraduate students are trained by the institutions of higher education. Therefore, strengthening the ties and cooperation between the Academy of Sciences and the universities and colleges and creating a favorable

environment for this kind of cooperation is very important to the development of scientific research in China. The opening of the laboratories to outsiders makes it possible to merge the massive research force of the universities and colleges and that of the academy into one organic whole, demonstrating the superiority of an association between research, education, and production.

Opening Up, the Inevitable Trend

The idea of opening up the laboratories won wide approval in the scientific circles the first time it was mentioned. From August 1985 to January 1986, 113 scientists from inside and outside the academy and 17 foreign scientists had come to the first group of 17 laboratories and 2 research institutes opened to outsiders to work as institute and laboratory directors or chairman and members of academic committees. More than 600 scientists from the academy or elsewhere will come to work in the near future. Among nearly 600 research project applications, more than 360 have been approved by the academic committees of the laboratories and institutes. Among the projects, about 40 percent are proposed by outsiders, and about 30 percent are cooperative projects between academy and non-academy personnel (including international cooperative projects). Taking part in these research projects are nearly 1,200 people, among whom more than 700 are non-academy scholars (including foreigners).

In China, the trend is for scientific research institutes to open to the public. The open laboratories should become laboratories for all scientists in China. On the basis of past experience, the Chinese Academy of Sciences is in the process of establishing and perfecting a management system for open laboratories. In the near future, more and better laboratories will be opened to scientists at home and abroad.

The opening up of laboratories is yet another new attempt in reforming the scientific and technological management system, a "new thing" in the scientific and technological circles. It will inevitably encounter some difficulties and problems. But one thing is certain, and that is, opening is inevitable and will have a positive and far-reaching influence on the faster development of science and technology in China.

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NATIONAL DEVELOPMENTS

STUDENTS ASSUME IMPORTANT ROLES AFTER STUDIES ABROAD

Beijing RENMIN RIBAO in Chinese 26 Mar 86 p 3

[Article by Song Bin [1345 2430]]

[Text] Returned students from the China University of Science and Technology, having completed their studies abroad and come back to teach, are gradually joining the ranks of the backbone of the faculty of this university. In educational and research work they are increasingly taking on ever more important roles.

Since 1978, the China University of Science and Technology has sent students, one after the other, to engage in advanced studies abroad in 18 countries. Now there are 183 returned students who have completed their studies and returned, including nine people who have earned Doctorates abroad. This batch of returned students is offering nearly a hundred new courses and handling over twenty seminars and research classes of every type. There are over 60 people who have taken responsibility as faculty advisors for the Masters' research students. On the one hand they are responsible for educational work, while on the other hand they are also engaged in scientific research, having achieved results in 34 scientific and technological areas and received awards in six fields. In 1981, Feng Keqin [7458 0344 0530], a lecturer in the mathematics department, came home from his advanced studies in the United States and became vice-chairman of the mathematics department, accepting responsibility for the algebraic theory of numbers, algebra and for taking care of the tasks of education and scientific research in mathematics. He was the first in the country to offer undergraduate and graduate courses in "The Algebraic Theory of Numbers," "Homological Algebra," "fen yuan yu li lun" [0433 0954 1068 3810 6158] and other high level courses, all well received by the students. At the same time, he has delivered over ten addresses to national journals and conferences, written over 350,000 characters of teaching materials, translated three volumes of foreign writings and filled some of the void in our country's science of algebra.

Some of the returned students are exhibiting their skill on some of the nation's key construction projects. Construction of the China University of Science and Technology' Synchronistic Radiation Laboratory was started at the end of 1984. Before this, the school sent ten young and middle-aged professors abroad, one after the other, to gain specialized knowledge of the physics of

the design and construction of accelerators. After they had returned to the country, they played key roles in this critical engineering project. Thirty-nine year old Yao Zhiyuan [1202 1807 0337] accepted the post of deputy-chief engineer of accelerator engineering, becoming one of our country's youngest accelerator specialists. Among this batch of returned students there are 13 professors, 70 associate professors and more than a few department chairmen and teaching and research section chiefs.

Many returned students and personnel are actively participating in the school's educational reforms. They are using their experience of advanced study abroad, joining education with reality and taking the lead in implementing the reform of the system of organization, education and teaching materials. Upon his return, Professor of Chemistry Wen Yuankai [3306 0337 0418] became chairman of his teaching and research section, implemented a bold exploration of the educational and research organization and achieved some preliminary results.

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NATIONAL DEVELOPMENT

SONG KIAN ON MAPPING OUT HIGH TECHNOLOGY DEVELOPMENT PLAN

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 8 Apr 86 p 1

[Article by Wu Ming [0702 2494]]

[Text] Speaking today before Chinese and foreign experts on economics and technology, Chinese Academy of Sciences Chairman Song Kian said that China was formulating a plan of high technology development in line with the condition of the country, emphasizing the opening up of and research into some new technological domains. This plan's objective lies in the implementation of the "Spark Plan" which uses science and technology to invigorate local economies. It will use science and technology to make a big contribution to the accelerated development of our national economy.

At the opening today of the Second Beijing International Conference on Science and Technology Policy, arranged by the Science and Technology Development Research Center of the Chinese Academy of Sciences, 40 foreign specialists and UN officials and over twenty Chinese experts participated. The Conference inquired into the strategies and policy problems of present-day technological development.

Delivering the opening address, Song Jian said that these problems are all pressing problems confronting China's development. The science and technology development plans and policies mapped out in recent years, including policies for reform of the science and technology system, are fundamentally suitable for solving these problems, promoting the service of science and technology to economic construction and giving full play to the enormous potential of science and technology for modernization and construction.

UN Science and Technology Chairman La-ka-ka and Chinese Science and Technology Vice-Chairman Wu Mingyu [0702 2494 3342] gave talks at the opening ceremony. The UNDP Beijing Resident Manager Kulaijiang also attended the opening ceremony and gave a speech.

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STATE COUNCILLOR VIEWS DEVELOPMENT OF SCIENCE, TECHNOLOGY

HK260902 Hong Kong LIAOWANG OVERSEAS EDITION in Chinese No 16, 21 Apr 86 pp 6-7

[Article by LIAOWANG reporter: "State Councillor Song Jian Talks About China's Strategy for the Development of Science and Technology"]

[Text] Learning that Song Jian, minister of the Science and Technology Commission, has been appointed a state councillor, LIAOWANG reporters asked this leader to talk about China's principles and plans for the development of science and technology. Although, during the fourth session of the Sixth NPC, Song Jiang was extremely busy with his work, he still readily agreed to be interviewed by LIAOWANG in his office.

An Expert-type Leader

Song Jiang is an outstanding expert in cybernetics and space engineering in China. In the early fifties, he graduated from Moscow (Borman) [Boa man 0545 2581] Engineering College in the Soviet Union. Later on, recommended by the college, he became a graduate student of Professor Frederbaum [Fei lie de bao mu 6316 0441 1795 0545 1191], a noted cyberneticist. In 1960, he obtained his associate [fu 0479] doctor's degree.

After returning to China, he worked for a long period of time in departments of national defense engaging in missile manufacture and research. In the pioneer stage of China's missile cause, he took charge of the overall design of the control system of China's first-generation ground-to-air missiles and made outstanding contributions to the design, the testing, and the finalization of designs of the missile control system, as well as the resolution of various key technical issues. This expert who was once a vice minister, as well as the chief engineer, of the Ministry of Astronautics Industry, was also one of the leaders in the research and testing of China's land-based missiles and communications satellites. He even published several dozen academic articles at home and abroad and won state scientific awards on many occasions. Because of his contributions to cybernetics and other fields, he was elected a member of the Council of the International Federation of Automatic Control in 1984 and also appointed foreign correspondent academician of the Mexican Engineering Academy.

In the early sixties, Qian Xuesen entrusted Song Jiang to revise his noted works "Engineering Cybernetics." Song Jiang revised the book splendidly and increased

the wordage of the book from 400,000 to 1.2 million. In the preface to the book, Qian Xuesen wrote that "the authors of the new edition of 'Engineering Cybernetics' are young Chinese cyberneticists who were trained and brought up precisely in this period. They, in particular Comrade Song Jiang, took the lead in organizing the work, personally took part in writing and finalizing the book, and finished most of the work. Therefore, they are the authors of the new edition." As this book won the state award for outstanding scientific work in 1982, Qian Xuesen even praised him on many occasions, saying that "at present, Song Qiang is an authority on cybernetics in China." The population cybernetics founded by him is a model integrating natural science with social science and has been highly priased by scholars at home and abroad.

At present, Song Jian has taken the leadership in the scientific and technological circles in the country for over a year. As an organizer and leader in the reform of the scientific and technological structure, he must have some distinctive views on the present situation and the prospects of Chinese scientific and technological circles.

This reporter asked: "We learned that it was you who vigorously initiated the noted "spark plan" and gave it its name. What, then, are the focal points of the scientific and technological work in the future?"

Smiling and speaking in Putonghua, with an accent of Rongcheng in Shangdong Province, this 54-year-old scientist in a grew western-style suit said that "You are a guest. Let me first of all pour you a cup of water." Instead of directly answering my question, he first talked about the situation on the scientific and technological front, which was of interest to everyone.

The Present Situation in Scientific and Technological Circles

"The situation in scientific and technological circles in the last few years can be described as unprecedentedly excellent. Great changes have taken place, in not only the mental attitude of the scientific and technological personnel but also in the integration of scientific and technological work with economic construction. Since the 3d plenary session of the 11th CPC Central Committee, the party's policy on intellectuals of bringing order out of chaos has begun to be implemented in scientific and technological circles. Because science and technology have been explicitly defined as productive forces, and intellectuals as an important component part of the working class, the enthusiasm of scientific and technological personnel for scientific research and technological development has been greatly aroused. Later, the CPC Central Committee also issued two decisions regarding the economic structural reform and the scientific and technological reform; and the party put forward the principle that economic construction must rely on science and technology and scientific and technological work must be geared to economic construction, which has already captured the hearts of the people. Therefore, with unprecedented zeal, the vast numbers of scientific and technological personnel rushed to production practice one after another to find their topics for study and to serve production in various forms. As a result, the long-standing phenomenon that scientific research is out of line with production being changed rapidly.

Song Jian cited a host of facts to illustrate that the direction of scientific and technological structural reform decided on by the CPC Central Committee is totally correct. He said "with no major deviations, the reform is being carried out smoothly."

Next, Song Jian talked about the issue that the opening of technology markets is particularly empahsized in the decision regarding scientific and technological structural reform. He said: "The technology market has been brisk. Last year, the confirmed business volume of the technology trade in the whole country exceeded 2.3 billion yuan. Between science and technology and production sectors, there are also various combinations or jointly run organizations. Undoubtedly, the emergence of this kind of lateral combined organization going beyond the limits of trade and region, has pounded strongly at departmental ownership and made the relation between science and technology and production enter a new stage. Gratifying achievements have also been made in other fields, like making the scientific and technological institutes of national defense serve civil production, putting military achievements into civil use, and so on. Thousands upon thousands of scientific and technological personnel have left their ivory towers to go to the medium-sized and small enterprises or townships, towns, and countryside to provide technical advice and spread scientific and technological knowledge. And the townships, towns, and countryside, where technology has always been in great demand, warmly receive the scientific and technological personnel like welcoming rain after a long drought."

Song Jiang said that the reform has not only expedited the promotion and application of scientific and technological achievements and accelerated the vitalization of the economy, but has also brought vitality to the scientific and research institutes. Last year, of the over 4,000 developing-type scientific research institutions at and above the level of prefecture and city, 316 institutions should totally independently pay their operating expenses, an increase of nearly 100 percent over 1984.

He said that: "During the reform, every department and region has acted with caution and held the opinions of intellectuals in very high regard. In particular, in the reform of operating expenses, they do not seek uniformity. Of course, in reform there are still some issues of understanding and real problems to be seriously solved. Although the reform of the scientific and technological structure is an extremely complex project of the social system, it seems, however, that its development is healthy on the whole."

Tow Major Things to be Done in This Year's Scientific and Technological Reform

Talking about plans for the future reform, Song Jian said: "Make steady progress." He said that "there are two major things to be done in this year's scientific and technological reform. First, comprehensively carry out the reform of the appropriation system. It is necessary to grasp well the following points: To carefully classify the research institutes and deal with them in different ways and vigorously promote the implementation of the contract system for technology; to set up national natural science funds and greatly increase the appropriations for basic and applied scientific research; to cooperate with banks to open up credit channels for science and technology; and so on. Second, to practice generally the appointment system for professional posts. This is

a major reform of the management system of professionals and aimed at inspiring intellectuals to go all out and at promoting the rational flow of qualified people. Meanwhile, the implementation of the appointment system can also solve the problem of irrational remuneration for middle-aged intellectuals. This work has a bearing on the immediate interests of the vast numbers of intellectuals, as well as on the existence and development of the several thousand research institutions. Therefore, it is imperative to act with caution and prudence."

Talking about the new technological revolution which is now arising in the world, this reporter asked whether necessary readjustment should be made to China's strategy for the development of science and technology. After thinking about it for a while, Song Jian said: "From the viewpoint of development, I think that necessary readjustment should be properly made in our country's stragegy for the development of science and technology. From now on it is necessary to accelerate the research of the burgeoning technologies and to put the stress on supporting the development of the burgeoning industries. While centering on the requirement of the technological progress of large enterprises to organize the tackling of key scientific and technological problems, it is also necessary to place support for the technological progress of medium-sized and small enterprises and township and town enterprises on the agenda. This year we shall emphatically grasp well the implementation of the "spark plan" and work out a long-term plan for the development of the burgeoning technologies."

Bringing the Enthusiasm of Scientific and Technological Personnel into full Play

It is very important to bring the enthusiasm of scientific and technological personnel into full play in carrying out the four modernizations drive. Song Jiang said: "The previous long-term principle of "unity, education, and reform" regarding intellectuals can no longer suit today's situation. I think we should thoroughly discard those extremely erroneous comcepts and practices toward intellectuals which were shaped under the guiding ideology of "taking class struggle as the key link" and firmly establish the concept that Chinese intellectual circles are an important component part of the working class "and devise new working methods in the light of this concept."

He also cited some noteworthy tendencies which are unfavorable to bringing the roles of scientific and technological personnel into play. For example, issues concerning the rational flow and part-time jobs of scientific and technological personnel. Recently, some units have tended to regard, and to ban, the legal part-time jobs of scientific and technological personnel as "an unhealthy tendency." This is wrong. At present, the lack of knowledge and qualified people is still a serious problem in our country. Meanwhile, some units let qualified people to stay idle--excessively. Therefore, allowing scientific and technological people to properly take part-time jobs can increase the benefit to the whole society and bring into full play the role of scientific and technological personnel and is welcomed by the people. Nevertheless, some localities still do not pay enough attention to middle-aged and young scientific and technological personnel. As most of these scientific and technolgoical personnel, in particular those in their fifties, are the backbone and leaders of the present

scientific and technological work, and can play the role of inheriting the past and ushering in the future, attention should be paid to them and they should be given sufficient opportunity to render service to the country.

Attaching Importance to Seeking Truth from Facts and to Innovation

Song Jian holds that it is very important to let science and technology play its proper role in the building of material and spiritual civilizations in our country, so as to raise the scientific and cultural levels of the whole nation. During the process of reform, the scientific and technological departments and personnel should be duty-bound to spread and popularize scientific and technological knowledge among the masses. He said that we favor the suggestion put foward by the Ministry of Agriculture, Animal Husbandry and Fishery to run a channel especially for the countryside via a broadcasting satellite to popularize scientific and technological knowledge among the people of the whole country.

With some philosophical words, Song Jian concluded the interview. He said: "We, the people engaging in scientific research, should attach importance to seeking truth from facts and to the spirit of innovation. Our aim is to seek new knowledge and to reform those regulations, taboos, and commandments fettering the development of the productive forces. When engaging in scientific research, people should not be the least big hypocritical. Any true scientist should know that only by freeing himself from old ideas, doing away with superstitions, and seeking truth from facts can be become ever-victorious. Therefore, I think that in the building of spiritual civilization we should spread widely and bring into full play this spirit of seeking truth from facts and of innovation."

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CSO: 4008/2104

NATIONAL DEVELOPMENTS

SICHUAN S&T PERSONNEL AID TOWNSHIP, TOWN ENTERPRISES

Shanghai WEN HUI BAO in Chinese 3 Mar 86 p 1

[Article by reporters Shen Zhuanxin [3088 1413 0207] and Deng Zhong [6772 6850]]

[Text] In order to bring modern science and technology to the industries of rural villages, more than 10,000 of Sichuan's science and technology personnel are helping to raise the management level of small and medium-sized township and town enterprises and are promoting technological progress. This activity is being carried out directly under the orders of the Sichuan provincial government.

Sichuan Governor Jian Minkuan [5592 3046 1401] realizes that science and technology, information and knowledge are required to make Sichuan wealthy as soon as possible. In promoting production in the peasant villages, science and technology are inseparable from the development of the commodity economy. Only when the commodity economy is developed to a certain level can science and technology be applied to the intensive requirements of productions. At present, there are many localities in Sichuan with self-sufficient small peasant economies, especially among the minotiry peoples dwelling in the mountainous regions and outlying districts, who lack the concept of a commodity economy. Moreover, lacking this kind of concept, they also lack any enthusiasm for the development of commodity production and naturally can have no interest in science and technology. When they arrived at the villages, the science and technology personnel had to develop a commodity economy to set an example for the farmers.

These 10,000 science and technology personnel were all transferred from institures of higher learning, scientific research units and large factories. The process of helping small and medium-sized township and town enterprises takes many forms. Some of them make up a cooperative network of science and technology personnel, forming a rather complete cooperative brigade of specialists serving the local small and medium-sized township and town enterprises. Some allow the technologically superior enterprises and resource-rich locations to sign joint agreements, and help by fitting in with their vocational specialties. Some produce many kinds of joint entities passing on their managerial knowledge to the town and township enterprises and cultivating talent. Some are building science and technology service organizations, providing consultation and leadership to the small and medium-sized township

and town enterprises. And some have chosen suitable comprehensive experimental bases for the institutions of higher learning to carry out education, research and the promotion of mutual cooperation, trained a large backbone of science and technology for the peasant villages, and promoted the production of local enterprises.

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NATIONAL DEVELOPMENTS

BRIEFS

FOREIGN EXPERTS IN BEIJING--Song Jian, state councillor and minister in charge of the State Science and Technology Commission, met at the Great Hall of the People this morning with foreign representatives and experts attending the Second Multinational instrument and Meter Symposium in Beijing. During his cordial and friendly conversation with them, Song Jian hoped that the experts from various countries would continue to exchange instrument and meter technologies with China and to cooperate in this regard. [Text] [Beijing Domestic Service in Mandarin 1200 GMT 19 Apr 86 OW] /12232

GENEVA EXHIBIT PARTICIPANTS--Beijing, 24 April (XINHUA)--The Chinese delegation to the 14th Geneva International Invention and New Technology Exhibition returned to Beijing today, bringing back 38 prizes won from the exhibition. A welcome ceremony was held at the Beijing airport by the State Scientific and Technological Commission. Song Jian, state councillor and minister in charge of the State Scientific and Technological Commission, delivered a welcome speech and extended his congratulations to the participants on behalf of the State Council and the State Scientific and Technological Commission. He urged the comrades to continue to exert themselves to create more and better inventions and new technologies and make even greater contributions to the four modernizations. Present at the ceremony were Zhou Gucheng, vice chairman of the NPC Standing Committee; Qian Xuesen, vice chairman of the CPPCC National Committee; and the leaders concerned of the State Scientific and Technological Commission, the State Education Commission, the National Defense Science, Technology and Industry Commission, the All-China Federation of Trade Unions, and the Ministry of Machine-Building Industry. [By reporter Wu Ming] [Excerpts] [Beijing XINHUA Domestic Service in Chinese 1702 GMT 24 Apr 86 OW] /12232

SHANGHAI TECHNOLOGY FAIR--a new technologies and new industries fair which reflects Shanghai's efforts and achievements in developing advanced science and technology opened at the Shanghai Exhibition Center yesterday morning. Rui Xingwen, secretary of the Shanghai Municipal CPC Committee, visited the fair yesterday. He also wrote an inscription which reads: Shanghai must constantly develop new technologies in order to maintain its superiority. The fair displays 617 research results submitted by 210 units of 26 departments, including the departments of instruments and meters, machinery, and electric appliance industries. They fall into the following 10 categories: optical [fiber] communications, processing by radiation, new energies, robotics, microcomputer control for industrial use, microelectronics, bioengineering, new materials,

warning devices, and sensors. The entire fair can be characterized by the words: new, complete, and useful. Liu Zhenyuan, vice mayor of Shanghai, cut the ribbon at the opening of the fair yesterday. [Text] [Shanghai City Service in Mandarin 0100 GMT 27 Apr 86 OW] /12232

JIANGSU ENGINEERING MEETING--The leading group for the Yangzi Ethylene Project held its third meeting on 28 April to study ways to ensure the fulfillment of the general target of trial operation of the first-stage project by July 1987. Gu Xiulian, Jiangsu governor; Zhang Xuwu, vice governor; Chen Jinhua, general manager of China National Petrochemical Corporation; and responsible comrades of the State Council, provincial, and municipal departments concerned attended the meeting. [Excerpts] [Nanjing Jiangsu Provincial Service in Mandarin 2300 GMT 30 Apr 86 OW] /12232

SHANGHAI COOPERATIVE VENTURE--Shanghai--The city's first cooperative venture in the field of technical consulting opens here today. Shanghai Daedalus Technical Consultancy Service Centre is jointly established by Daedalus Industries Ltd, a U.S.-Italian venture, Shanghai Pharmaceutical Industries Design Institute and Shanghai Investment and Trust Corporation. "In its modernization drive," Claudio Mayer, general of Daedalus told CHINA DAILY, "China has avoided many mistakes made by most developing countries in the world. "It is necessary to find out the real technical need of Chinese factories so as to avoid blind investment and waste," he said. The centre, specializing in the transfer of technical know-how rather than equipment, will focus its efforts on industrial development of the Shanghai Economic Zone, said Wang Hengchuan, chairman of the board. [By staff reporter Zhen Fan] [Text] [Beijing CHINA DAILY in English 24 Apr 86 p 2] /12232

SHANGHAI CITY DEVELOPMENT--Shanghai, 3 May (XINHUA)--Shanghai Institutes of the Chinese Academy of Sciences are helping the city develop bioengineering, new chemical materials, microelectronics and radiation technology, a local newspaper reported. A radiation technology center jointly run by the academy's Shanghai Institute of Nuclear Research and 11 city departments and enterprises has already gone into experimental operation, said WENHUI DAILY. The center has a daily capacity to keep 10 tons of fruit and vegetables fresh by using radiation, and can also disinfect medical equipment. Three other centers of bioengineering, microelectronics and chemical materials are being built in Shanghai. When completed, the bioengineering center will carry out research into gene engineering, cell engineering, microbiology and enzyme engineering. The microelectronics center will work on developing computers, large integrated circuits and optical-riber communications. The chemical materials center will develop high molecular compounds, the newspaper quoted local scientists as saying. [Text] [Beijing XINHUA in English 1036 GMT 3 May 86 OW] /12232

SCIENTIFIC ACHIEVEMENTS--Beijing, 3 May (XINHUA)--Almost 4,000 scientific achievements have been made in China over the past 5 years, many of which have provided big economic benefits, according to the science and technology commission. More than 3,000 of these achievements from scientific research projects carried out during the Sixth 5-Year Plan (1981-1985) are now being used to boost production, a commission official here said. The development of 270 superior crop strains has increased the country's annual grain output by 10 million tons. New water-injection technology has helped China's biggest

oilfield, Daqing, in Heilongjiang Province, to produce an additional 427 million barrels of crude oil over the past 5 years. Research projects were carried out in various fields, including agriculture, energy, transport, raw materials, machine-building, electronics, light industry, new technology and social development. They involved more than 100,000 scientific and technical workers from 5,000 research institutes, colleges and enterprises. [Text] [Beijing XINHUA in English 0725 GMT 3 May 86 OW] /12232

CSO: 4010/2016

APPLIED SCIENCES

METHOD FOR CODING CHINESE CHARACTERS

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 20 No 12, 1983 pp 52-56

[Article by Gu Deyi [7357 1795 5030] of Hubei Provincial Electronics Research Institute: "A Tree-Structured Chinese Letter Coding Method for Chinese Characters"]

[Text] Abstract: The tree-structured Chinese letter coding method for Chinese characters takes the structural grammar of Chinese characters and their syntax tree as a theoretical base, and makes direct use of 36 pairs of Chinese letters (each pair of letters corresponding to a numeral or to an English letter) to form a code for Chinese characters, while using an English keyboard. This method has the advantages of directly perceivable code, convenient rules, and quick keyboard entry. It is convenient for popularizing and dissemination. It is suitable for managing news in Chinese by electronic computer, for compilation of Chinese dictionaries, as well as for transmission of telegrams.

I. Preface

For the coding of Chinese characters we can look back to China's Eastern Han period [A.D. 25-220] when Xu Shen [c. 58 to c. 147] first created the method of arrangement by radical. He distributed 9,353 characters under 540 radicals, compiling the "Analytical Dictionary of Characters" [better known as "Shuowen jiezi," or just "Shuowen"], China's first systematic analysis of the forms of Chinese characters. Because this method of compilation revealed the complex internal structure of Chinese characters it has been passed on to us today. Some dictionaries published at present have only reduced the number of radicals somewhat, as with the "New China Single-Character Dictionary" [Xinhua zidian] with its 189 radicals, and the "Dictionary of Modern Chinese" [Xiandai Hanyu cidian] with 188. Consequently, looking up characters according to the method of arrangement by radical is too slow, and we could not even mention knowing a code just by looking at the character.

Wang Yunwu [3769 7189 0063], former director of the Commercial Publishing House, created a four-corner code method for looking up characters, which for the first time solved the problem of "knowing a code by looking at the character." This kind of coding method is still an authoritative coding

method day. In addition to being used in the "Four-Corner New Dictionary" [Sijiao haoma xin cidian], a four-corner code finding list is prefaced to the "Dictionary of Modern Chinese" and appended to the new edition of "Word Sources" [Ci Yuan]. However, incidence of duplicated codes is too high with this method, and it cannot meet the requirements of computers. We should know that there are many aspects involved in the creation of duplicated codes.

Using the coding of the characters "wang" 王 and "dou" 豆 as examples, their codes would be 1010 for both. Reasons for the occurrence of the same code are:

(i) The four-corner method considers only the characteristics of the four-corners of a Chinese character and disregards the inner structure of the character. As it happens, the fundamental distinction between "wang" and "dou" is just in the middle.

(ii) It is said that we are using the four corners of these two characters, but the corners that are actually used are only the top-left and the bottom-left.

From this look back at the history of Chinese character coding we must draw the following conclusions: only by paying attention to the fundamental point about the complex inner structure of character shapes will it be possible to come up with an advanced coding scheme.

The "tree-structured Chinese letter coding method for Chinese characters" (to be abbreviated as "tree" method) is proposed on just that basis of learning from the history of character coding in China. It takes as its theoretical basis the structural grammar of Chinese characters and their syntax tree, and directly takes 36 pairs of Chinese letters (extracted from tens of thousands of Chinese characters, where each pair of Chinese letters corresponds to only one numeral or to one English letter) as codes for Chinese characters, and what is more, uses a ready-made English language keyboard.

After experiments on the Apple II in our office, as well as experiments by the Wuhan Institute of Water Transport Engineering on the Water Transport's WANG 2200 VP, we have proved that this kind of coding method has the advantages of directly perceived code, convenient rules, quick keyboard entry, no need for memorization, nor for any need to refer to romanization.

II. Analysis of the Structure of Chinese Characters

Just as matter is composed of molecules, Chinese characters are formed by the combination of a few small pieces. These small pieces that make up characters we shall simply call pieces. There are all sorts of shapes for these pieces, as where some are square, some triangular, and some concave with any edges.

The relations of strokes within the pieces, one to another, are intricate and complex. Those pieces where the strokes are horizontally and vertically intersecting and linked, as with "丰," "王," "为"...are all intersecting

linked pieces. Those pieces where the strokes are not joined, as in "氵," "三," and "立," are separated pieces. Pieces where a piece is contained within a piece, as with "国," "田"...are enveloped pieces. Where pieces are entwined one with another, as with "臾," they are entwined pieces. The pieces we have just discussed may be jointly called component elements.

2.1 Relational Operations of Pieces

2.1.1 The relation is top to bottom, ABOVE (or ⊕)

Piece X_1 is above piece X_2, which is notated as X_1 ABOVE X_2. The form of this structure is as in Figure 1a.

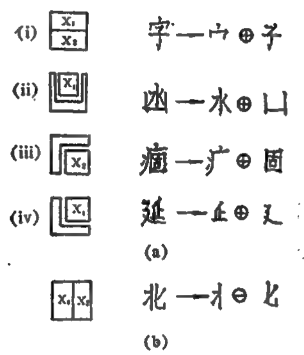

Figure 1

2.1.2 A left to right relation, LEFT (or ⊖)

Piece X_1 is to the left of X_2, which is notated X_1 LEFT X_2. The form of this structure is as in Figure 1b.

2.1.3 With the enveloped relation, INCLUDE (OR ⊛)

Piece X_1 includes piece X_2, which is notated X_1 INCLUDE X_2. The form of this structure is as in Figure 2a.

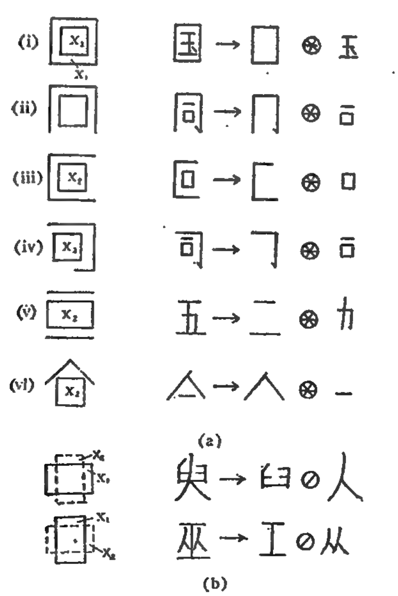

Figure 2

2.1.4 With the entwined relation, INSERT (or)

Insert piece X_2 into piece X_1, which is notated X_1 INSERT X_2. The form of this structure is as in Figure 2b.

[Translator's note: The meanings of the characters used in the figures have no significance whatsoever, although the following should be noted: the character preceding each caption numeral is the word for "figure"; at the top of Figure 4 there are two explanations for the diagrams immediately below: the left four-character phrase says "first-level breakdown," and the right four-character phrase says "second-level breakdown."]

2.2 Breakdown of Chinese Characters

The breakdown of characters is divided into two levels. A breakdown that only involves the top/bottom and left/right relational operation symbols is a first-level breakdown. This action divides the character into component elements. The breakdown of the component elements is the second-level breakdown. That action breaks the component elements down still further into particles. For an example, let us breakdown the character "翕" [xi 5047].

The first-level breakdown is as indicated in Figure 3a, and the second-level is as in Figure 3b.

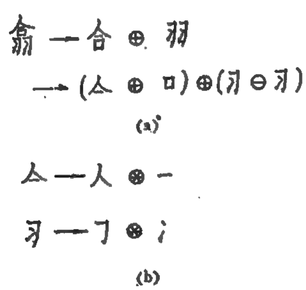

Figure 3

The two levels of breakdown may be shown in a syntax tree, as in Figure 4.

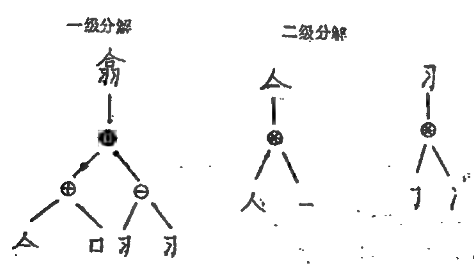

Figure 4

2.3 Tree-Structure Analysis for First-Level Breakdown

When doing a tree-structure analysis for a character breakdown we put the most important elements into the first-level breakdown. Since the important point of this article is the search for Chinese character coding, and to simplify notation, in the analysis below we will discard the relational operation symbols. We will use CW to represent a Chinese character and B to represent a component element. After a character has undergone first-level breakdown we will have the tree structures representing the various conditions shown in Figure 5.

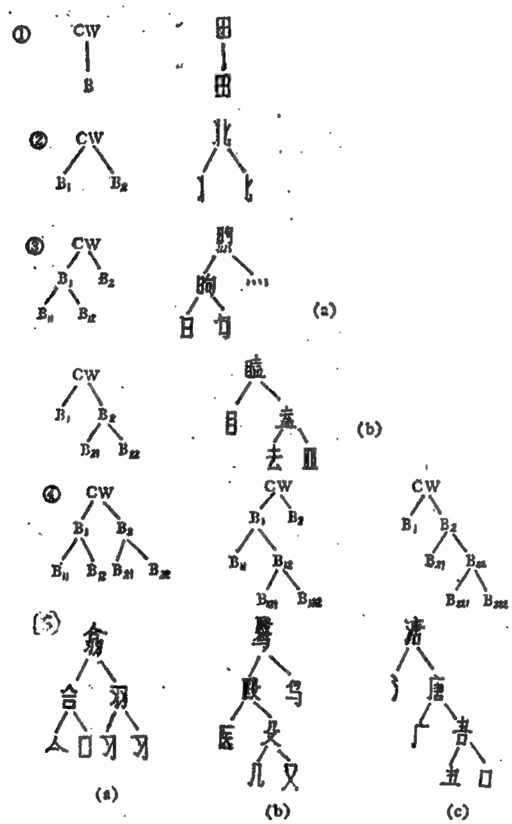

Figure 5

An extremely few characters have four and more banches, as in Figure 6.

Collectively notate the leaves of the tree root CW as LEAVE(CW).

[Translator: Author might be unaware that the singular of "leaves" is "leaf."]

Gathering together the leaves of the five kinds of trees noted above, we can use the following five forms to summarize respectively as:

$$\mathrm{LEAVE(CW)}=\{B\}$$
$$\mathrm{LEAVE(CW)}=\{B_1,\ B_2\}$$
$$\mathrm{LEAVE(CW)}=\{B_1,\ B_2,\ B_3\}$$
$$\mathrm{LEAVE(CW)}=\{B_1,\ B_2,\ B_3,\ B_4\}$$
$$\mathrm{LEAVE(CW)}=\{B_1,\ B_2,\ B_3,\ B_4,\ B_5\}$$

All of which leads to the following conclusions:

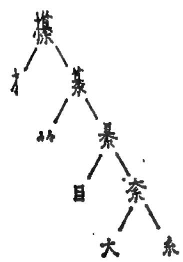

Figure 6

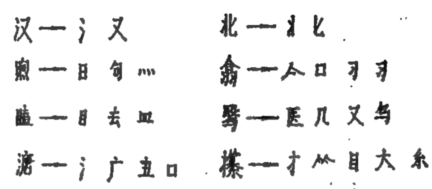

Figure 7

i) "Component elements" [fen kuai 0433 1040] of Chinese characters are the leaves of the syntax tree from first-level breakdown; ii) among Chinese characters, component elements possess the positional relations of top, bottom, left, and right. However, in the syntax tree the component elements are placed into a relation of order of precedence; iii) in the syntax tree, the sequential relation of component elements is fundamentally the same as the component elements in correct calligraphy.

Based on this conclusion, we can directly carry out first-level breakdown on characters according to the sequence of the component elements in correct calligraphy. See Figure 7.

III. Chinese Letters

Thirty-six pairs of script symbols have been extracted from the results of breaking down tens of thousands of Chinese characters to act as Chinese letters, for which, see the appendix. Chinese letters appear in pairs, each pair of letters corresponding to a numeral or to an English letter. In other words, each pair of Chinese letters corresponds to one ASCII code. The letter pair "乚,木", for example, corresponds to the English letter "A."

Chinese letters are divided into two types. Type A are 36 symbols in common use, like "乚,⺈," etc.; Type B are 36 character-component radicals that represent a large number of characters, and which are moreover Chinese characters in themselves, like "木,之," etc.

For some statistics on the "radical capacity" of the 1971 revised and rearranged edition of the "New China Single-Character Dictionary" see the appendix. Of the approximate 8,500 characters in that dictionary, if one divides the characters into the 189 radicals, the character-component radicals appearing among the Chinese letters will cover 7,955 of the characters [translator: i.e., if you consider the 189 radicals that are also in the list of Chinese letters, then count the number of characters listed in the dictionary under those particular radicals, you will find 7,955]. This accounts for 93.59 percent of all the characters contained within the dictionary. This shows that the Chinese letters have a strong capacity for forming characters. Type A symbols are further divided into four divisions.

First division, basic strokes, like "丶一丨……"
Second division, intersecting script marks, like "×力十……"
Third division, corner script marks, like "冂凵……"
Fourth division, isolated script marks, like "丄二……"

This makes it convenient for us to give an order to the Chinese letters, and at the same time and more importantly, to help in comparing the sizes of Chinese characters.

IV. Structural Patterns for Chinese Characters

The following expressions use Polish notation. Also, the interconnecting pieces that can be changed into top/bottom structure or into left/right structure are called transform pieces.

Grammar G = V_N, V_T, P, S)

where V_N = {<character>, <piece>, <component element>, <transform piece>, <entwined/enveloped pieces>, <isolated pieces>, <letters>}

V_T = {ABOVE, LEFT INCLUDE, INSERT, 丶, 一, 冂, 凵, ×, 力, 木, 之……}.

S = <Chinese character>

moreover P: <character>::=<piece>

<piece>::=<piece><piece>ABOVE|<piece><piece>LEFT|<component element>
<component element>::=<letter>|<entwined/enveloped pieces>|<isolated pieces>|<transform pieces>
<entwined/enveloped pieces>::=<piece><piece>INCLUDE|<piece><piece>INSERT
<isolated pieces>::=<piece><piece>ABOVE|<piece><piece>LEFT
<transform pieces>::=<piece><piece>ABOVE|<piece><piece>LEFT
<letter>::= 、|一|冂|凵|×|力|木|之……|

V. The "Tree" Method

5.1 The "tree" method

1. If a Chinese character is not a component element, then do a first-level breakdown of tree structure. If LEAVE(CW)={B_1,...B_N}, here

   N = 2,3,4,5

1.1 If N=2, separately do second-level breakdowns on B_1, B_2, and limit division to 2 pieces. Go to statement 3.

1.2 If N>3, go to statement 3.

2. If a character is a component element, then do a second-level breakdown.

3. Take as code the largest letters of each piece to represent a piece.

For the characters in section 2.3 of this article, find the code as shown in Figure 8.

5.2 Handling duplicated codes

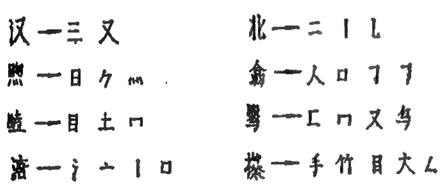

Figure 8

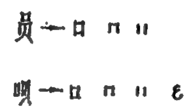

Figure 9

Use the method by which a null symbol $\mathcal{E}$ [epsilon] is appended to a duplicated code in order to distinguish the duplicated codes (see Figure 9).

VI. Characteristics of the "Tree" Method

1. Chinese letters are directly perceivable, and the capability for organizing characters is great. Type A script markings are remarkably similar to Japanese kana. This shows the depth and attainment of ancient Japanese studies of Chinese characters, and at the same time goes to show that our use of Chinese letters is correct. [Translator: The Japanese kana, or phonetic symbols, used today to represent the sounds of the Japanese language, were derived from the far more complex Chinese full characters.]

2. The "tree" method is simple and clear, does not require memorization, and is quick for code recognition. No matter what country a person is from, as long as he or she can correctly write Chinese characters, then he or she will be able to do a tree structure first-level breakdown of Chinese characters according to the order of precedence in writing the component elements, and

will be able as well to code them. His or her speed will be no less than that of writing an English word.

3. The length of the average character code is short, and the rate of duplicated characters is low. The "tree" method is not restricted to understanding a few corners of Chinese characters, as it does a level by level analysis of the characters, and breaks the characters down into component elements. Moreover, by continuing to break the component elements down into particles, this deeply reveals the complex inner structure of Chinese characters. Consequently, we achieve the results where average code length is short and the rate of duplication is low. Taking the more than 6,000 characters from the May 1982 publication of "A Manual for Quick and Concentrated Recognition of Characters" as examples, the rate of duplicated codes is only 0.3 percent, with an average code length of 2.5.

4. The "tree" method provides for an ingenious arrangement of high frequency characters as well as for radicals that represent a large number of characters. What is more, the codes for high frequency Chinese characters are determined directly from the provisions of the "tree" method. Also, the code is short and there is no need to set up a table of simplified code. The average code length for the top 20 high-frequency characters is only 1.75.

5. Entropy and coding efficiency.

$$\text{(efficiency)}\ \eta = \frac{\text{the entropy value of Chinese characters}}{\text{decision making capacity about each symbol} \times \text{quantity of symbols}}$$

With an entropy value of 8.821 for Chinese characters, the quantity of tree structure symbols is 2.5. Decision making capacity = $\log_2 36 \approx 5.17$ (SHAN NON [sic, probably SHANNON]), which is

$$\eta = \frac{8.821}{5.17 \times 2.5} \approx 68.23 \text{ percent}$$

At present, the four-figure telegraphic code of the Ministry of Posts and Telecommunications has the highest coding efficiency, but it is only 66 percent.

The "tree" method that this writer has proposed has received the help of Comrade Xiong Qianxing [3574 0467 5281] of the Wuhan Institute of Water Transport Engineering, and of Comrade Qiu Fengzhang [6726 7364 4545] of this office, which I gratefully acknowledge.

Appendix: Chart of Radical Capacity (total character count of 8,500)

Radical	Capacity	%	Radical	Capacity	%	Radical	Capacity	%
氵	515	6.06	疒	125	1.47	母*	55	0.65
艹	490	5.75	山	125	1.47	田	55	0.65
口	415	4.88	日	120	1.41	人	55	0.65
木	410	4.85	丿	110	1.29	十	50	0.59
扌	385	4.52	鸟	110	1.29	厂	50	0.59
亻	320	3.76	目	100	1.18	巾	50	0.59
钅	280	3.29	禾	100	1.18	力	50	0.59
月	225	2.65	心	100	1.18	戈	50	0.59
土	215	2.53	衤	100	1.18	尸	50	0.59
虫	200	2.35	刂	95	1.12	礻*	50	0.59
纟	200	2.35	鱼	95	1.12	囗	50	0.59
讠	175	2.06	犭	95	1.12	攵	50	0.59
竹	170	2.00	宀	85	1.00	米*	50	0.59
忄	170	2.00	马	75	0.88	弓	40	0.47
阝	165	1.94	贝*	75	0.88	刀	40	0.47
女	150	1.76	饣*	70	0.82	耳	35	0.41
之	145	1.71	二	70	0.82	小	35	0.41
火	145	1.71	广*	70	0.82	冫	35	0.35
石	140	1.65	乙	65	0.76	灬	30	0.35
王	135	1.59	门	60	0.71	水	20	0.24
足	130	1.53	大	55	0.65	⋮	⋮	⋮
一	125	1.47	八	55	0.65			

*These radicals have never appeared as Chinese letters before.

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APPLIED SCIENCES

DESCRIPTION OF HARDWARE FOR CHINESE CHARACTER PROCESSING

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 20 No 10, 1983 pp 45-48

[Article by Liu Bangjun [0491 6721 0689], Ministry of Finance Computer Center: "Setting Up Chinese Character Processing Systems That Use Mid-Size and Minicomputers"]

[Text] Abstract: This article talks about mid-size and minicomputer Chinese writing and processing system hardware and equipment, and selection standards for number of characters, character patterns, fonts, attributes, and coding regions. It also uses actual examples to explain several problems that ought to be considered when setting up systems.

Chinese character processing systems that use mid-size and minicomputers have various functions like fast batch input of the characters, high speed high quality printing of the characters, linking together of many Chinese character terminals, and abundant Chinese character processing software, with which microcomputer Chinese character processing systems have no way to compare. However, the price of large and complete systems is high, they take a long time to set up, and are certainly not needed by all users. In order to reasonably deploy systems and to quicken the pace of set ups, we ought to consider carefully the following points.

I. Preparations Before System Set Up

1. Investigate the Scope of the Processing Activity

a. When the characters used in the output result and the positions on the paper that is printed are all fixed and unchanging, where only the numerals change, preprinted paper may be used, handling in ordinary ways; if the characters and positions will change according to input parameters and the results of calculations, then Chinese character processing systems must be used.

b. If it is just that [less than about 100] fixed characters are used, they may be augmented within the symbol and graphics generator of ordinary terminals and be output on a stylus printer, or, a character drum printer with a small quantity of Chinese characters, or a character chain line printer may

be selected for use. A Chinese character processing system is not necessarily needed. If the quantity of Chinese characters used is great, then a Chinese character processing system must be used.

c. If there is only the storage of, inquiry into, or retrieval of Chinese character material and simple editorial processing, having nothing to do with high speed inputting and outputting of Chinese characters, then it would be more economical to use microcomputer Chinese character processing systems; if high speed, large quantity input and output of Chinese is needed, or if there is need for rather complicated Chinese character editorial processing, then only mid-size and minicomputer Chinese character processing systems can satisfy the requirements for speed, capacity, and equipment linkage.

d. If it is just handling of Chinese character report forms, or processing of Chinese character keyboard retrieval of materials, etc., activity that has no connection with Chinese character attributes, there is no need to establish records with Chinese character attributes within the system; if there is a need to retrieve with attributes, or if one needs to use the attributes of Chinese characters to process Chinese, then one must have attribute records and corresponding attribute processing programs.

2. Investigate the Amount of Activity and the Quantity of Data

a. Determine the proportions of jobs pertaining to batch processing, time-sharing processing, or real-time processing occupy; and then further determine the proportion of handling Chinese characters in each type of processing system. In Chinese character processing jobs, representative work is best first test-processed on other systems, checking on processing time and the storage space used.

b. Investigate the daily average amount of Chinese character input and output, and amount of input and output on peak days.

c. Look into the largest number of terminals used and the largest acceptable response time.

d. Investigate the resident disk data capacity concerned with Chinese character processing: the quantity of matrices data for character patterns in the script library; the amount of attribute data for Chinese character records; the amount of format data for printing table formats; amount of materials data for on-line retrieval using Chinese characters; amount of special purpose program data for Chinese character processing.

3. Investigate the requirements for Chinese character output quality: how many kinds of characters will be used, which kinds of fonts are needed, how many kinds of character pattern dimensions are needed, how high are the requirements for clarity, and how high are the requirements for preserv-ability.

4. Investigate the scope of personnel utilization for Chinese character terminals and keyboards: specialists or ordinary personnel; younger or older.

5. Investigate the performance and pricing, as well as mode of transport for character pattern, attribute, and Chinese character software of the Chinese character processing systems already set up.

II. Selection of Hardware and Equipment

1. Chinese Character Input Equipment (see Table 1)

Table 1

Type	Input Speed	Merit	Deficiencies
1	Resident characters on a large keyboard, 20 to 25 per minute; stroke patterned mid-sized keyboard determined by coding speed and keystrokes for each character; small keyboard (ordinary keyboard), same as 3.	Direct input and display of Chinese characters; easy to collate and revise; suitable for batch processing.	High price.
2	Keyboard input speed same as 1; time for sreen update dependent upon equipment, overall speed somewhat less than 1.	Suitable for on-line processing, rest same as 1.	Same as above.
3	Ordinary keyboard 250 to 300 keystrokes per minute, counting 4 keystrokes per character, when the most codes have been memorized can reach 60 to 70 characters per minute.	Can use original equipment; reasonably priced; fast.	Cannot directly input, display, collate, or revise characters.
4	Determined by equipment, no connection with operator.	Automatic entry.	At present, accuracy is lacking.

There are currently four kinds: (1) off-line input with special purpose equipment; (2) on-line Chinese character terminal; (3) non-Chinese character equipment is substituted; (4) OCR.

May select equipment types based on requirements and funds; may select number of installations according to data quantity and entry speed.

The merits and deficiences of various keyboards are indicted in Table 2 [on following page].

Primary criteria for keyboard selection is the scope of the utilizing personnel.

Specialized equipment for off-line Chinese character input has the following new functions to aid selection:

(1) A portion of or all of character pattern matrices can be altered by the user.

(2) Chinese characters within the keyboard can be selected by the user, and after selection, the conversion table between keyboard position and Chinese character codes can be changed by software methods.

(3) Entry format can be determined at will, Chinese character codes and non-Chinese character codes may be mixed in input according to format, and the equipment will automatically take care of the conversion symbol.

(4) In addition to display of Chinese characters and input format, can simultaneously display operation states and error codes.

Chinese character terminals have the following new functions to aid selection:

(1) and (2) are same as above.

(3) Screen display can scroll up, down, left, and right, many individual screens can be joined together to form a large screen, and can be output through the printer provided with the terminal.

(4) Screen information may first be saved in the floppy disk in the terminal controller, and after filling up or under command may be transferred to the host in one quick move.

(5) Intelligent terminals.

2. Chinese character output equipment

We already have: (1) laser Chinese character printers; (2) laser phototypesetters; (3) xerographic printer; (4) ink jet printer; (5) stylus Chinese character printer; (6) optical fiber Chinese character printer; (7) LED Chinese character printer. The performance of the first five are listed in Table 3 [following after Table 2].

Table 2

Mode	Capacity of Keyboard Surface	Keyboard Universality	Code Uniqueness	Input Speed	Price	Ease of Code Retention	Scope of Utilizing Personnel
Chinese character keyboard	Limited	Deficient	Good	Slow	High	Keyboard resident characters, easy; characters not in keyboard, difficult	Ordinary personnel
Stroke patterned keyboard	Unlimited	Medium	Medium	Medium	Medium	Medium	Those who have received training
Pronun-ciation coded	Unlimited	Good	Deficient	Fast	Low	Medium	Those who have received training
Tele-graphic code inter-national code	Unlimited	Good	Good	Fast	Low	Difficult	Specialist personnel

Table 3

Type		Printer Speed	Quality of Printed Character	Color of Printed Character	Paper Used	Preservability	Pricing	Applicable Range
1	(Dry)	Highest	Good (10–12 dots per mm)	Monochrome	Plain paper	Good	Equipment is expensive	Medium and large computers
	(Wet)	Medium	Good	Monochrome	Special paper	Rather good	Equipment is expensive, paper is expensive	Mini-computer
2		Medium	Best (30–40 dots per mm)	—	Sensitized surface	Good	Equipment is expensive	Medium and mini-computers
3		High	Low	Monochrome	Special paper	Lacking	Unavailable	Medium and large computers
4		Low	Good	Color	Plain paper	Medium	Unavailable	Mini-computer
5		Lowest (40–80 charac-ters per second)	Lowest (4–6 dots per mm)	2 colors are possible	Plain paper	Medium	Inexpensive	Terminal, micro-computer

Functions that can be selected are among those below: (1) format forms overlap, thin film overlap; (2) character pattern expand and contract; (3) copy embellishment; (4) a part or all of a character pattern can be altered by user; (5) external character handling; (6) printing characters of different dimensions within one line; (7) printing line of emphasis below a character; (8) printing chart script; (9) controlling with function characters; (10) using one printer by two host computers; (11) linking off-line output directly to magnetic tape machine; (12) changing usable paper dimensions (page length, page width); (13) self-checking diagnostics.

Capacity of script library in output equipment is in general 4,000, 8,000, and 16,000 characters of various kinds, the majority of systems (financial and accounting processing, warehouse management, directing, and dispatching) actually using between 1,000 and 3,000 characters.

Primary considerations for selection of equipment: (1) quality and use of the output result; (2) output speed; (3) capacity of script library; (4) matching to host computer; (5) RAS [reliability, availability, serviceability]; (6) price.

3. Host computer, disks, channels

Only if the host computer, disks, and channels match can the functions of the Chinese character processing equipment be fully realized, see Table 4.

Table 4

Speed of Chinese Character Printer (8 lines per inch, 110 char. per line)	Processing Speed with Mated Host[1]	Added Disk Capacity for C. Char.[2] Processing	Rate of data Transfer Through Connected Channels
20,000 lines per minute	over 2 million operations per second	over 500 MB	over 1.5 MB per second
7,000 lines per minute	over 1 million operations per second	over 300 MB	over 1.5 MB per second
2,700 lines per minute	over 500,000 operations per second	over 200 MB	over 1 MB per second
700 lines per minute	200,000 operations per second	over 100 MB	50 KB per second

Explanation: (1) If the host computer does only input and output of Chinese characters, speed will be appropriately lower;
(2) Listed capacity is for conditions of general forms processing; for Chinese character search, capacity will be determined by report quantity.

III. Selection of Number of Characters, Character Patterns, Character Fonts, Attributes, and Coding Regions

1. Number of Characters

a. For the overall number of Chinese characters in the scope of the business of statistical processing, refer to the international "information exchange using the basic set of Chinese character codes and character set" for determining the capacity of the system character store (either disk or tape) and the characters to be chosen.

b. Based on the capacity of the script library in the input and output equipment, determine which characters are to be placed in the equipment character store from the system character storage.

c. Within some equipment the character store is divided into the two portions of high speed look-up and low speed look-up, so from among the characters selected in b. above, select out further those characters of highest frequency for high speed look-up.

d. With large Chinese character keyboards one should select which characters are to be placed into the keyboard based on the statistical table of frequency of character use within the scope of the processing task.

2. Character Patterns, Character Fonts (see Table 5)

a. Determine how large a character pattern matrix to use and what fonts to use based on use and the total number of characters in the system character storage. If restructuring already available equipment then you are also restricted by the limits of that equipment itself.

b. Report headings use large Song fonts and boldface; notes use small Song font. These characters can be prepared beforehand from the system character storage, and also marking bits may be used to allow a 32 X 32 matrix to automatically expand or contract.

Table 5

Use	Character Pattern Matrix	Fonts	Number of Characters That May Be Accurately Expressed
Printing control board for typesetting system	more than 100 X 100	Song, boldface	All Chinese characters (approximately more than 50,000)
Printing of formal documents, forms, etc.	32 X 32 or 30 X 30	Song and boldface	Same as above
Terminal or off-line Chinese character input display or copy output on a stylus printer	24 X 24	Song	About 100 Chinese characters cannot be expressed
	16 X 18 15 X 17 15 X 16 14 X 15 14 X 14 13 X 13	"sans serif" "sans serif" "sans serif" "sans serif" "sans serif" "sans serif"	40 cannot 60 cannot 100 cannot 200 cannot 400 cannot 800 cannot

3. Attributes

These indicate the form, sound, and meaning of Chinese characters and their transformations. For example, radicals, stroke count, order of strokes, stroke pattern code, four-corner code, word root, etc., are all attributes of "pattern"; romanization letters (or phonetic symbols) with tone added to give the reading pronunciation, the various readings for characters with more than one pronunciation, dialects, ancient Chinese pronunciation, etc., are all attributes of "sound"; meanings of characters, limits of normal usage (maps,

surnames, medicinal, ...), capacity for word formation, etc., are all attributes of "meaning." The page numbers and entry numbers of single-character dictionaries and phrase dictionaries that record the above mentioned matters may also be considered as attributes.

Selection of attributes is completely determined according to the recording format for use and attributes.

4. Coding Region (see Figure 1)

International 7-bit scheme bit coding must be converted to 8-bit Chinese character coding before it can be processed by computer, and the principles of conversion should be: 1 complete conversion to a permissable region of utilization is guaranteed; 2 the conversion formula be simple and uniform; 3 when international words expand in the future, points 1 and 2 will still be satisfied; 4 original software and hardware provisions are met.

Region I in Figure 1 would thus be of no benefit for expansion.

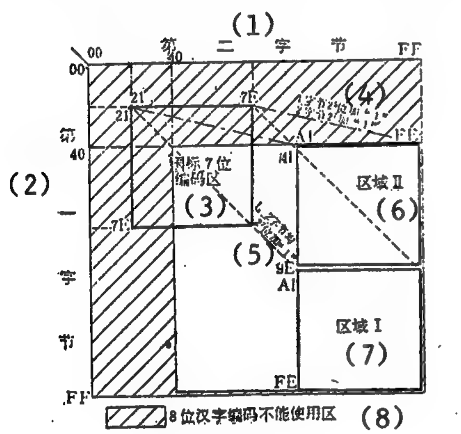

Figure 1

Key:

1. The second byte
2. The first byte
3. International 7-bit coding region
4. First [or possibly just "one"] byte 2^5 bits add "1"
   Second [or possible just "two"] byte 2^7 bits add "1"
5. 1, 2 bytes all 2^7 bits add "1"
6. Region II
7. Region I
8. Area that cannot be utilized by 8-bit Chinese character coding

IV. Statistics On The Amount of Work In the Set Up of the Ministry of Finance's Chinese Character Processing System (Table 6)

Time	Work Content	Working Time	Machine Time
May 1981	Japanese Hitachi M-150 Chinese character processing system introduced	--	--
Jan-May 1981	Scope of character usage for financial jobs and statistics on frequency	300 working days	--
Apr 1981	Transfer of 32 X 32 matrix Chinese character patterns	--	--
Jun-Sep 1981	Check-up, revision, supplementing the 32 X 32 matrix character patterns, creation of 16 X 18 character pattern	380 working days	--
Jul-Oct 1981	Created and supplementary character patterns entered (200,000 records)	figured according to records	--
May-Jul 1981	Common characters used in finance selected, characters selected for inclusion in keyboard, keyboard designed, printed	180 working days	--
May-Dec 1981	Character patterns revised, writing and debugging of relevant programs for keyboard revision	100 working days	--
May-Dec 1981	Restructuring of machines used in the Chinese character processing system		210 hours
1982	Further revision of character patterns attribute records, etc., in operation		

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APPLIED SCIENCES

NEW PROCEDURE FOR DESIGN OF TWT DESCRIBED

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11, No 4, Jul 83 pp 48-52

[Article by Lu Zhongzuo [7120 6988 4373], Nanjing Institute of Technology: "A New Procedure for the Design of TWT;" received January 1983, finalized in March 1983]

[Text] Text of English Abstract: Up to the present, the design methods for TWT are still those founded in the 1950's and 60's. The design of the TWT usually starts by selecting the value of a in the range of 1.2-1.6, then calculating the related internal working parameters and the dimensions of the tube until the performance criteria for the tube are satisfied. Such a design method cannot bring the internal working parameters and the dimensions of the TWT into a suitable working region after the first run calculation. A cut and try approach is needed, and this causes some obscurity for a greenhorn designer.

A new procedure in the design method is presented. This new design procedure starts from the small signal gain parameter working region diagram[2], selecting a suitable working region, setting out a working point at the center of the frequency band and obtaining the working point value of b, QC and x_1, and then calculating the dynamic working curve of the whole frequency band. From this dynamic working curve, we can see clearly on the region diagram whether the working region selected is satisfactory or not. And on this region diagram, we can judge whether there is any possibility of performance improvements of the TWT, and if necessary, see how to move the working point to a better region. Such kind of selection and determination by the region diagram method makes the designer's mind clear and avoids obscurity.

This new procedure can be used for design of small signal gain TWT, of high efficiency and high power tubes, and of super wide band TWT.

I. Introduction

The customary method of designing TWTs is basically still the method established in the 50's and 60's. There are many types and performance standards for TWT, but in design calculations they can often be divided

into two aspects: one is the design of small signal gain, and the other is the design of efficiency and output power. In design, the width of the pass-band, size of the perveance, the degree of linearity, the dispersion formation of the slow-wave helix, etc., should be taken into consideration.

The basis of gain design is Pierce's small signal gain theory but the basis for efficiency and power design is the large signal theory of Tian Binggeng [3944 3521 5087] and Rowe, Cutler's experimental data and Scott's conclusion that slow-wave line terminal gain should be greater than 26dB.

TWT design computations are generally conducted based on indicators for the tube's external technical performance (such as working voltage, working current, gain decibels, efficiency, output power, and pass-band), and design computations for the TWT's dimensions and internal working parameters such as γa, b, QC, K, R_0, and p_u) are conducted to achieve the external technical performance indicators required. With different dimensions and internal working parameters of the TWT, different external performance indicators can be obtained. Thus the goal of design is to determine the suitable working range of the internal working parameters to satisfy the external technical performance indicators.

The usual TWT design method is to select at a central frequency a value of a to start with [1] (usually γa=1.2-1.6) and then one by one compute the TWT's dimensions, internal working parameters and external technical performance again and again until the necessary external technical performance is obtained. Because this design method is a trial and error design process of repeatedly selecting values and repeatedly computing [1], even if the external technical performance indicators required are obtained, it cannot be determined in which region the TWT's external working parameters are located, whether or not there is untapped potential, etc. Thus, there is a certain obscurity in design, and it is especially difficult for beginners to arrive at the design values. It is also difficult to tell if the tubes have been designed to the optimal working state.

This paper takes the small signal gain parameter working region diagram [2] as a new procedure in design. This procedure can be both a beginning procedure in TWT design and also can be a final procedure after the first cycle of design computations for a TWT. In terms of the diagram, first of all an appropriate working region is selected and the work point of the central frequency is set out, and the dynamic work curve of the entire frequency band range is found, so that in one look at the diagram one can tell whether or not the TWT internal working parameter situation selected is appropriate, whether or not there is still room for improving the tube's performance, where the working point should be shifted to improve the tube's performance, etc. From this method of tracking information one can know what is going on and avoid designing blindly.

II. Small Signal Gain Parameter Working Region Diagram

The TWT gain relationship is given by Pierce's small signal theory:

$$G=A+BCN-\alpha L=A+54.5x_1CN-\alpha L \tag{1}$$

or

$$G'=54.5x_1CN \tag{2}$$

From Eq.(2) one can see that the important part of TWT gain is BCN=54,5x_1CN. Apart from Pierce's relational equation, the value of x_1 can also be given from Kats's small signal working equation[3]:

$$\begin{aligned}&\delta^4-j\frac{2}{C}\delta^3+\left[\frac{2b}{C}+b^2-d^2+\frac{4QC}{(1-C\sqrt{4QC})^2}-j2d\left(b+\frac{1}{C}\right)\right]\delta^2\\&-j\frac{8QC}{C(1-C\sqrt{4QC})^2}\delta+\frac{2}{C}\left\{(1+bC)^3+\frac{4QC}{(1-C\sqrt{4QC})^2}\left[b\right.\right.\\&\left.\left.+\frac{C}{2}(b^2-d^2)\right]-jd(1+bC)\left[\frac{4QC}{(1-C\sqrt{4QC})^2}+C(1+bC)\right]\right\}=0\end{aligned} \tag{3}$$

in which, δ=x-jy.

$$C=\sqrt[3]{KI_0/4V_0} \tag{4}$$

$$b=\frac{1}{C}\left(\frac{u_0}{v_p}-1\right) \tag{5}$$

$$QC=\frac{1}{4C^2}\left(\frac{\omega_q}{\omega}\right)^2 \tag{6}$$

$$d=0.01836L/CN \tag{7}$$

Eq.(3) is a complex coefficient quartic equation: there are four complex roots for each group of the internal TWT working parameters C,b,QC, and d. It indicates the four components of gain wave, back wave, decadent wave, and equivalent wave that exist within the tube. The real part of the gain wave δ, is the value of x_1. Thus the TWT gain Eq.(3) is determined by its internal working parameters, and different internal working parameters obtain different external technical performance.

Using a computer to carry out the computations on Eq.(3)[4], we obtain d=0.05-0.15, C=0.05-0.15, QC=0.1-1.0, and b=-1-3.2, and the relational curve of the range of x_1 values which are illustrated in Figures 1 and 2. We call Figure 2 the gain parameter working diagram[2]. The relational equation between b_{x1max} and QC under maximum gain indicated by the broken lines in the figure is:

$$b_{x_1\max}\approx\sqrt{4QC} \tag{8)*}$$

*Eqs.(7.2, 13) on page 242 of ZHONG, XIAOGONG XINGBOGUAN SHEJI SHOUCE [MEDIUM AND SMALL POWER TWT DESIGN HANDBOOK] are incorrect, as can be seen when they are plotted in the small signal parameter working region diagram.

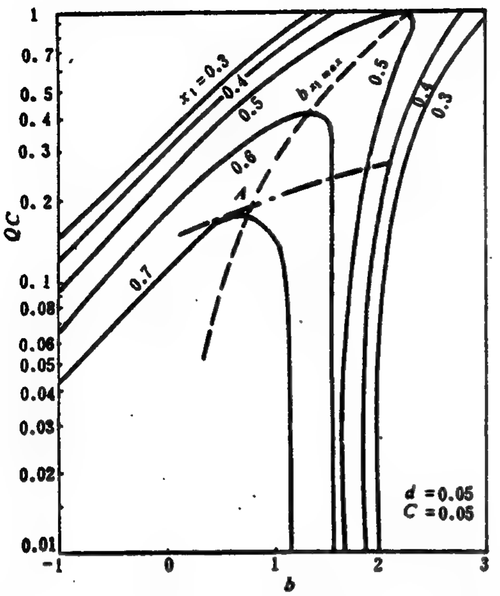

Figure 1. Parameters obtained from Kats's relational equation

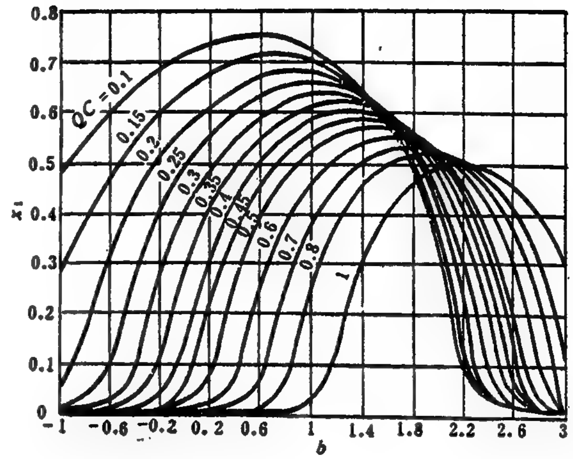

Figure 2. Gain parameter working region diagram

III. Display of Dispersion Formation Technology in the Gain Parameter Working Region Diagram

For new modern TWT dispersion formation technology is frequently used to improve the tube's performance. Dispersion formation technology is that speed after slow-wave loading will diminish as the frequency band changes and thus the b value of the tube diminishes within the entire frequency band and the incline of the dynamic work curve will increase greatly in the gain parameter working region diagram. If the load action on the helix is very great it becomes a non-dispersion helix and thus the dynamic work curve is nearly perpendicular in the diagram. If the load action on the helix is even greater, even to cause negative dispersion, the gradient of the dynamic work curve on the diagram will also become a negative gradient. From this we know that dispersion formation technology causes changes in the gradient or position of the dynamic work curve in the gain parameter working region diagram and thus brings about different TWT performance.

IV. Display of Resynchronous Technology in the Gain Parameter Working Region Diagram

Adoption of resynchronous technology can improve the efficiency of the TWT. This technology makes the phase velocity of the slow-wave line diminish or the electron injection direct current velocity increase, restoring the synchronous action of the injection and wave and strengthening energy exchange. At the same time, from Eq.(5) we know that the value of b will also increase with it, and thus will make the dynamic working curve shift to the right on the diagram and change the tube's performance. If the working point A in the original design has already been set at the right side of the maximum gain curve, after adopting resynchronous technology

the dynamic working curve will shift into an inappropriate region, the result will decrease the tube's performance. From the diagram, it can be clearly determined that if resynchronous technology is adopted, the working point of the original diagram should not be set too far to the right on the diagram.

V. New Measures in Designing the TWT

1. Working Point of the Small Signal Gain TWT

The special characteristic of small signal gain TWT is frequently that in the entire frequency section there is high and even gain. From the gain parameter working region diagram, the working point A of the high gain TWT should be at the position of the maximum gain dotted line and make the QC value diminish. For broad frequency tubes with level gain, the working point A can be in the left part and some dispersion formation technology used to make the gradient of the dynamic working curve nearly fit the top level x_1 curve.

After selecting the working point A, the b,QC, D, and x_1 values of this point can be determined from the diagram. From Eqs.(5) and (6) the corresponding working voltage V_0, working current I_0, and injection perveance p_μ. This demonstrates that the position of any point on the gain parameter working region diagram has its corresponding p_μ value. Thus, in designing tubes, the injection perveance should not be randomly selected but should be recalculated after the working point A has been determined from the diagram. After the working point has been determined on the diagram, the corresponding internal working parameters and the value of a selection can be obtained and thereupon design calculations for the TWT can be carried out normally. Since the working point A is determined appropriately the recalculation process is reduced to a minimum, facilitating the design calculations.

2. Working Points of High Efficiency, High Power TWT

On the basis C.C. Cutler's experimental data, the maximum efficiency of the TWT appears at QC=0.2 and γR_0=0.5-0.6. Thus the working point of a high efficiency TWT should be selected at QC=0.2 where the line is horizontal. The working point of high efficiency and high power TWT should be selected in the right hand part at QC=0.2 where the line is horizontal and the broken line of maximum gain. If the even gain must be considered in the frequency band, dispersion formation and selectively lowering of the a value can be adopted.

3. Working point of the Ultra-wide Band TWT

To obtain performance of an ultra-wide TWT it is necessary to adopt dispersion formation technology. Currently, both longitudinal metal strip or vane loading helixes are used. They obtain ultra-wide band operational performance by making the TWT's dynamic working curve shift its gradient.

The ultra-wide band TWT can also be divided into three types: (1) small-signal high-gain tubes; (2) high-efficiency high-power tubes; (3) high-efficiency low-power tubes. In design they also should choose different working points and adopt dispersion formation technology.

VI. Conclusion

The new TWT design procedures proposed in this paper initially select the working points under the central frequency from the gain parameter working region diagram. After the working point is selected, its corresponding C, b, QC, and d values can be obtained and its corresponding working voltage V_0, working current I_0 and injection perveance P_u can be found. After that, according to the normally determined γa value, the parameters and tube dimensions can be computed one by one. Determining the dynamic working curve in the diagram can clearly reveal whether or not the design results are in a good state and whether or not there is still potential for revision, and in what direction the working point should be shifted, so that the designer will have a very good idea of what is going on. Using this method of figuring things out by diagrams, a beginner can avoid designing blindly.

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APPLIED SCIENCES

MICROSTRIP MEANDER-LINE SLOW-WAVE STRUCTURE STUDIED

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11, No 4, Jul 83 pp 68-75

[Article by Peng Zi'an [1756 5261 1344], Beijing Vacuum Electron Devices Research Institute: "A Study of Microstrip Meander-line Slow-wave Structure;" received April 1982, finalized in October 1982]

[Text] Text of English Abstract: A field analysis of a double array microstrip meander-line slow-wave structure is reported. The potential function U(y,z) and the characteristic admittance of single conductor Y_C were calculated by a numerical method, and the characteristic dispersion equation and the coupling impedance expression for this structure were derived. The performance of the microstrip meander-line for different structural parameters were calculated by computer. Two such lines have been used in printed circuit TWTs, and experimental results come close to theoretical calculations.

I. Introduction

The typical method for meander-line slow-wave structure analysis is to use the multiconductor transmission model. R.C. Fletcher[1] established the theoretical model in 1952 (the basic hypotheses are: 1. propagating the TEM wave along the conductor's axis; 2. the vertical conductor axis can propagate electromagnetic waves), and applied the "field matching" method, first of all computing the characteristics of the interdigital lines (the approximation accepts digital space as homogeneous electrical field). Later, P.N. Butcher[2] studied infinitely thin conductor systems. In the 70's, microstrip meander-lines were applied in crossed field amplifiers, solid state traveling wave amplifiers and other devices, thus microstrip meander-line theoretical analysis and design methods aroused interest, and R. Sato[3] used microwave network analysis methods to study microstrip meander-line wave filters. J.A. Wiss[4] and R. Crampage[5] et al. used Green analytical method to compute microstrip meander-line (or interdigital line) characteristics. A.K. Agrawa[6] conducted further analysis on the coupling between the lines. Zhou Wen[7] et al. beginning from computing microstrip line capacitance, computed the characteristics of microstrip interdigital lines and the results conformed well with experiments.

This article used numerical computation methods for field analysis of microstrip double array meander-line systems and from this computed its characteristics. The computational results have been used in 5cm printed circuit TWT and conform well with measurement results.

II. Characteristic Admittance

Microstrip slow-wave structure uses thin-film technology on a dielectric base (see Figure 1). For this system, generally under high order mode cut-off frequencies, the high order mode propagated along the conductor's axis can be ignored[8]. The computations and analysis in this paper also ignored the influence of high order modes and drew on the basic hypotheses of multiconductor transmission line models in document [1]. The characteristic admittance Y_c can be defined as

$$Y_c = I/V \tag{1}$$

in which I is the current in the conductor and V is the potential in the conductor.

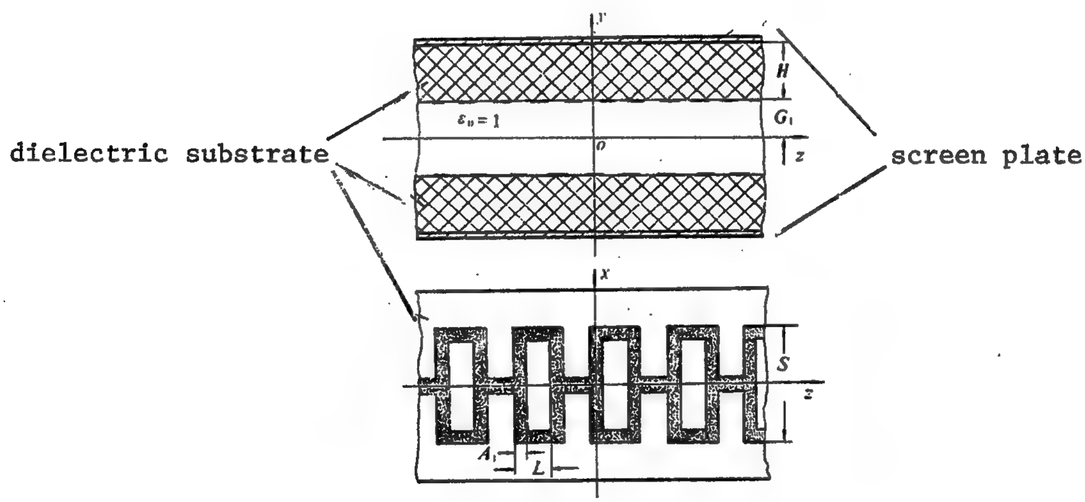


Figure 1. Microstrip Double Array Meander-line System

In TEM wave hypotheses there is the following relational equation:

$$I = \omega Q/k \tag{2}$$

in which ω is the angular frequency, Q is the charge of the unit length conductor, k is the propagation constant of the TEM wave in a homogenous dielectric $k=\omega\sqrt{\varepsilon}/c$ (ε is the dielectric constant, c is the speed of light).

In a non-homogenous dielectric system

$$k=\sqrt{\frac{Q}{Q_0}}\cdot\frac{\omega}{c} \tag{3}$$

in which Q_0 represents the charge on the unit length conductor when there is no dielectric in this system.

Substituting Eqs.(2) and (3) in (1) we get

$$Y_c=c\sqrt{QQ_0}/V \tag{4}$$

III. Using Numerical Computation Method to Find the Potential Function U(y,z) From Eq.(4) we know that the value of Y_c is determined by the values of Q, Q_0 and V and the problem of finding Q, Q_0, and V can be reduced to solving the electrical field E in the system.

On the basis of the hypothesis of TEM wave propagation along the conductor's axis, in this system, the intensity of the electrical field E, the potential ϕ and the potential function U in the system cross-section are respectively

$$E=-\nabla\phi(x,\ y,\ z) \tag{5}$$

$$\phi=U(y,\ z)(ae^{jkx}+be^{-jkx}) \tag{6}$$

$$\nabla^2_{yz}U(y,\ z)=0 \tag{7}$$

in which a and b are constants.

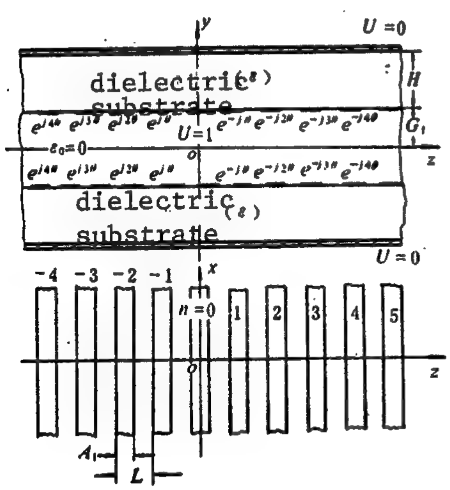
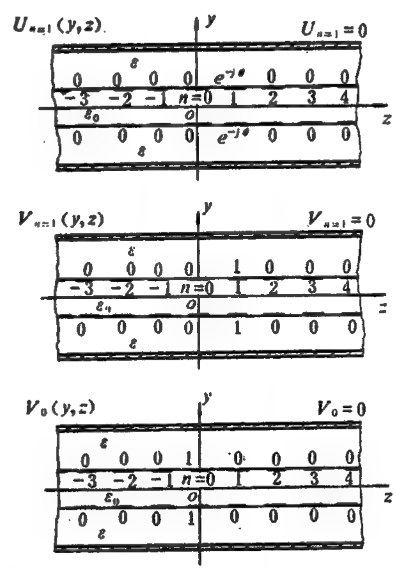


Figure 2. Structural Model of Computed value of U



(a) Boundary conditions corresponding to $U_{n=1}(y,z)$
(b) Boundary conditions corresponding to $V_{n=1}(y,z)$
(c) Boundary conditions corresponding to $V_0(y,z)$

Figure 3. Simplification of Boundary Conditions

From Eqs.(5), (6), and (7), it can be seen that solving the problem of electrical field is also solving the problem of the second order homogeneous partial differential equation (Laplace equation) in Eq.(7). We used a numerical computation method to find the value of U for each point on the space grid. Figure 2 gives a diagram of the multiconductor transmission line system corresponding to the system illustrated in Figure 1, this is the model used to compute the value of U. The structure has the following characteristics: (1) the Z axis is the system's axis of symmetry (symmetrical mode); (2) the system is a periodic structure, with period L, phase-shift θ, and n as a periodic number, thus we have

$$U(y, z+L)=U(y, z)e^{-j\beta L}=U(y, z)e^{-j\theta} \tag{8}$$

in which β is the propagation constant of the wave in the z direction, $\beta L=\theta$.

When the structure illustrated in Figure 2 does not change, if the potential on the conduction band is as illustrated in Figure 3(a), then the corresponding potential function is $U_{n=1}(y,z)$. If the potential on the n=2 band is $e^{-j2\theta}$, and the potential on the other bands is 0, the corresponding potential function is $U_{n=2}(y,z)$. Carrying out the analogy in this way, the potential function can be defined $U_{n=0}(y,z)$, $U_{n=-1}(y,z)$, $U_{n=-2}(y,z)$....

According to the principle of potential superposition, we can get

$$U(y, z)=U_{n=0}(y, z)+U_{n=1}(y, z)+U_{n=-1}(y, z)+U_{n=2}(y, z)+U_{n=-2}(y, z)+\cdots\cdots \tag{9}$$

If the potential on the conduction band is as illustrated in Figure 3(c), the corresponding potential function is $V_0(y,z)$.

The Figure 3(b) illustrates the conduction band potential distribution corresponding to potential function $V_{n=1}(y,z)$. The potential function can be similarly defined $V_{n=-1}(y,z)$, $V_{n=2}(y,z)$, $V_{n=-2}(y,z)$,.... Through transformation of coordinates we get

$$\begin{aligned}
V_{n=1}(y, z)&=V_0(y, z-L)\\
V_{n=-1}(y, z)&=V_0(y, z+L)\\
V_{n=2}(y, z)&=V_0(y, z-2L)\\
V_{n=-2}(y, z)&=V_0(y, z+2L)\\
&\cdots\cdots\\
V_{\pm n}(y, z)&=V_0(y, z\mp nL)
\end{aligned} \tag{10}$$

comparing Figures 3(a) and (b) we can see that

$$U_{n=1}(y, z)=V_{n=1}(y, z)e^{-j\theta}=V_0(y, z-L)e^{-j\theta}$$

and carrying out the analogy:

$$U_{n=-1}(y,\ z)=V_{n=-1}(y,\ z)e^{j\theta}=V_0(y,\ z+L)e^{j\theta}$$
$$U_{n=2}\ (y,\ z)=V_{n=2}(y,\ z)e^{-j2\theta}=V_0(y,\ z-2L)e^{-j2\theta}$$
$$U_{n=-2}(y,\ z)=V_{n=-2}(y,\ z)e^{j2\theta}=V_0(y,\ z+2L)e^{j2\theta}$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

at the same time $\quad U_{n=0}(y,z)=V_0(y,z)$

i.e.,

$$U_{n=0}(y,\ z)=V_0(y,\ z)$$
$$U_{\pm n}(y,\ z)=V_{\pm n}(y,\ z)e^{\mp jn\theta}=V_0(y,\ z\mp nL)e^{\mp jn\theta} \tag{11}$$

Substituting Eq.(11) in Eq.(9) we get

$$\begin{aligned} U(y,\ z)=&V_0(y,\ z)+V_0(y,\ z-L)e^{-j\theta}+V_0(y,\ z+L)e^{+j\theta} \\ &+V_0(y,\ z-2L)e^{-j2\theta}+V_0(y,\ z+2L)e^{+j2\theta}+\cdots\cdots \\ &+V_0(y,\ z+nL)e^{+jn\theta}+\cdots\cdots \qquad (z\neq 0) \end{aligned} \tag{12}$$

$$U(y,\ 0)=V_0(y,\ o)+\sum_{n=1}^{\infty}2V_0(y,\ nL)\cos n\theta \tag{13}$$

$$\begin{aligned} U(y,\ z)+U(y,-z)=&2V_0(y,\ z)+2\sum_{n=1}^{\infty}[V_0(y,\ z \\ &+nL)+V_0(y,-z+nL)]\cdot\cos n\theta \end{aligned} \tag{14}$$

From Eqs.(12-14) we can see that potential function U(y,z) can be expressed as the sum equation made up of the V_0 group, thus the task of solving U(y,z) first of all is solving $V_0(y,z)$. From Figure 3(c) we know that V_0 has the following characteristics: (1) when |n| is increased, $V_0(y,z)$ is oriented towards zero. Thus, as long as there is a limit in Eqs.(12), (13), and (14) sufficient precision can be guaranteed; (2) from the symmetry of boundary conditions we can get:

$$V_0(y,\ z)=V_0(y,\ -z);\ V_0(-y,\ z)=V_0(y,\ z) \tag{15}$$

thus, all that is necessary is to compute the potential function $V_0(y,z)$ within the first limit.

When the numerical computation method finds jie [0094] V_0, first of all the plane illustrated in Figure 3(c) is divided into grids, with intervals h. The y direction is numbered J and the z direction, I. The potential of any point in the grid (except points on the boundary)

$$\begin{aligned} V_{0,s+1}[I,\ J]=\frac{1}{4}\{&V_{0,s+1}[I,\ J+1]+V_{0,s+1}[I-1,\ J] \\ &+V_{0,s}[I+1,\ J]+V_{0,s}[I,\ J-1]\} \end{aligned} \tag{16}$$

in which the subscript S represents the number of iterations.

The points on the boundary should take values according to the method below:

(1) The entire conductor surface is an equipotential surface, for potential see Figure 3(c).

(2) depending on the demand for computation precision, the boundary in direction z can take the limit periodic number n.

(3) the equation which represents the value of points on the dielectric interfaces is as follows (y>0)[9]:

$$V_{0,s+1}[I,\ J]=\frac{1}{4}\{V_{0,s+1}[I-1,\ J]+V_{0,s}[I+1,\ J]\}+\{\varepsilon \cdot V_{0,s+1}[I,\ J+1]+\varepsilon_0 V_{0,s}[I,\ J-1]\}\cdot\frac{1}{2(\varepsilon+\varepsilon_0)} \tag{17}$$

(4) the points on axes y and z can be found using Eq.(15)

$$\left.\begin{aligned} V_{0,s+1}[0,\ J]&=\frac{1}{4}\{V_{0,s+1}[0,\ J-1]+V_{0,s}[0,\ J+1] \\ &\quad +2V_{0,s}\cdot[1,\ J]\} \\ V_{0,s+1}[I,\ 0]&=\frac{1}{4}\{V_{0,s+1}[I-1,\ 0]+V_{0,s}[I+1,\ 0] \\ &\quad +2V_{0,s+1}\cdot[I,\ 1]\} \end{aligned}\right\} \tag{18}$$

According to Gauss's law, the charge on the unit length conduction band is:

$$Q=\oint D\cdot dS \tag{19}$$

In the numerical solution method, the component of the potential shift vector D can be represented as potential difference:

$$\left.\begin{aligned} D_x&=\varepsilon\cdot\{U[I,\ J]-U[I+h,\ J]\}/h \\ D_y&=\varepsilon\cdot\{U[I,\ J]-U[I,\ J+h]\}/h \end{aligned}\right\} \tag{20}$$

Because the electrical field in the vicinity of the conduction band is not homogeneous, to improve the precision of the computations, some revisions are made in the computation process: the grids in the vicinity of the conduction band are doubled so that the potential computations are even more precise; the division of area in Eq.(19) should be a place suitably distant from the conduction band.

IV. Dispersion Characteristics and Coupling Impedance

Meander-line is a two step periodic system, with period 2L. It has two basic modes: basic traveling wave and basic back wave. The propagation constants of the two waves are $\beta_f=\theta/L,\ k_f;\ \beta_b=(\theta+\pi)/L,\ k_{b_0}$ respectively. Their characteristics admittance is: $Y_C(\theta)$ and $Y_C(\theta+\pi)$ respectively.

Dispersion equation of single meander-line

$$\mathrm{tg}^2\frac{\theta}{2}=\frac{Y_C(\theta)}{Y_C(\theta+\pi)}\mathrm{tg}\left(k_f\frac{S}{2}\right)\mathrm{tg}\left(k_b\frac{S}{2}\right) \tag{21}$$

S is the meander-line width. The dispersion equation of a dual meander-line which has already been derived is

$$\begin{aligned}\frac{Y_C(\theta)}{Y_C(\theta+\pi)}\mathrm{tg}^2\frac{\theta}{2}\left[\cos\left(k_f\frac{S}{2}\right)+\cos\left(k_b\frac{S}{2}\right)\right]^2 \\ =\left[\mathrm{tg}^2\frac{\theta}{2}\sin\left(k_b\frac{S}{2}\right)-\frac{Y_C(\theta)}{Y_C(\theta+\pi)}\sin\left(k_f\frac{S}{2}\right)\right]\left[\mathrm{tg}^2\frac{\theta}{2}\right. \\ \left.\cdot\sin\left(k_f\frac{S}{2}\right)-\frac{Y_C(\theta)}{Y_C(\theta+\pi)}\sin\left(k_b\frac{S}{2}\right)\right]\end{aligned} \tag{22}$$

coupling impedance[10]

$$K=\frac{|E_{z0}|^2}{2\beta_0 P}=\frac{|E_{z0}|^2}{2\beta_0 V_g W} \tag{23}$$

in which $|E_{z0}|$ is the amplitude of the E_z space harmonic wave (n=0); V_g is group velocity, W is average stored energy on the z direction unit length.

In the periodic structure, the field distribution also exhibits periodicity, and according to the Floquet theorem:

$$E_z(x,\ y,\ z)=\sum_{n=-\infty}^{\infty}E_{zn}(x,\ y)\exp(-j\beta_n z) \tag{24}$$

in which $\beta_n=(\theta+2\pi n)/L$ is the propagation constant of the n'th space harmonic wave.

$$E_{zn}=\frac{1}{L}\int_{-L/2}^{L/2}E_z(x,\ y,\ z)\exp j\beta_n z dz \tag{25}$$

and because $E_z=-\partial\phi/\partial z$, within the y,z plane we have

$$E_{zn}=-j\beta_n U_n \tag{26}$$

$$U_n=\frac{1}{L}=\int_{-L/2}^{L/2}U(y,\ z)\exp j\beta_n z dz \tag{27}$$

from Eqs.(12), (13) and (14) we get

$$U_n=\frac{1}{L}\int_{-\infty}^{\infty}V_0(y,\ z)\exp j\beta_n z dz\equiv V_{on} \tag{28}$$

From the dispersion characteristics we can get the group velocity

$$V_g=\frac{d\omega}{d\beta}\approx L\frac{\Delta\omega}{\Delta\theta} \tag{29}$$

based on the definition of average stored energy:

$$W=\frac{1}{2cL}\left[\int_{-S/2}^{S/2}|A\cos(k_b x)+B\sin(k_b x)|^2\sqrt{\left(\frac{Q}{Q_0}\right)_b}Y_C(\theta+\pi)dx+\int_{-S/2}^{S/2}|C\cos(k_t x)+D\sin(k_t x)|^2\sqrt{\left(\frac{Q}{Q_0}\right)_t}Y_C(\theta)dx\right] \tag{30}$$

in which A, B, C, and D are constants.

Taking into account the distribution of the field in directions x and y, the definition of average coupling impedance

$$\overline{K}=K\cdot G_x\cdot G_y \tag{31}$$

From U(y,z) we can compute the value of K(y) and get:

$$K\cdot G_y=\frac{1}{G}\int_0^G K(y)dz \tag{32}$$

$$G_x=\frac{1}{S\cdot C^2}\int_{-S/2}^{S/2}[C\cos(k_t x)+D\sin(k_t x)]^2 dx \tag{33}$$

For a single meander-line

$$G_x=\frac{1}{S}\left(\frac{S}{2}+\frac{1}{2}\frac{\sin(k_t S)}{k_t}\right) \tag{34}$$

For a double array meander-line

$$G_x=\left\{C^2\left[\frac{S}{2}+\frac{1}{2}\frac{\sin(k_t S)}{k_t}\right]+D^2\left[\frac{S}{2}-\frac{1}{2}\frac{\sin(k_t S)}{k_t}\right]-2CD\frac{1}{k_t}\sin^2\left(k_t\frac{S}{2}\right)\right\}\cdot\frac{1}{S\cdot C^2} \tag{35}$$

V. Results of Computations and Experiments

The results computed by the computer program on the microstrip meander-line characteristics are illustrated in Figures 4-8. Figure 4 gives the $\bar{K}$ and f curves when A_1/L value (L=1.2mm) changes. The impact of its coupling impedance is especially clear, when the A_1/L value is large, $\bar{K}$ increases. But when A_1/L draws close to 1, the harmonic wave component can increase and the normal ratio is about 0.5. From Figure 5 it can be seen that the distance G_1 between the two substrates also has a considerable influence on the value of $\bar{K}$: when G_1 is small the space intensity clearly increases and $\bar{K}$ increases; but at the same time it can limit the thickness of electron injection and cause problems for focusing. Thus only a moderate value of the two can be taken.

The dispersion characteristics of the meander line are influenced mainly by the substrate dielectric constant ε and the line length S (see Figures 6 and 7). They will determine the working frequency of the component and thus when the working frequency is improved and the corresponding S value is small they can limit the output power level of the component. Adopting a scheme of linking the double array meander-line or twin group meander-line can improve the output power level without changing the working frequency.

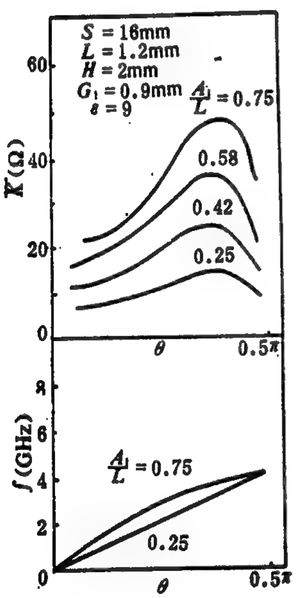


Figure 4
Influence on $\bar{K}$ and f when A_1/L changes

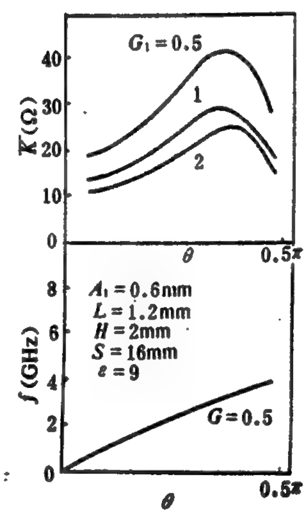


Figure 5
Influence on $\bar{K}$ and f of changes in G_1

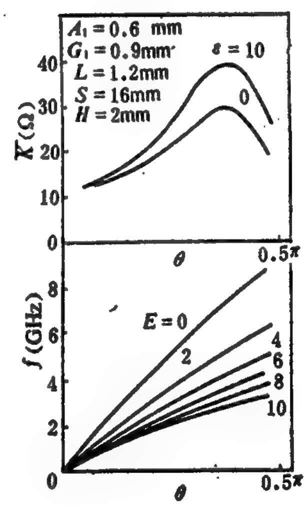


Figure 6
Influence on $\bar{K}$ and F of $\mathcal{E}$ value

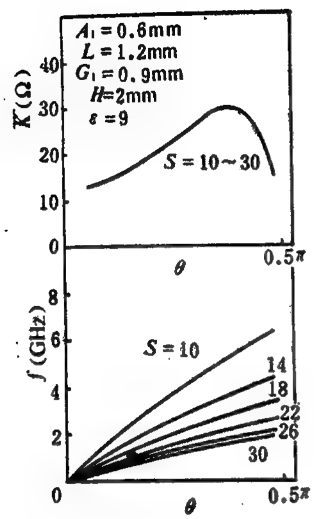


Figure 7
Influence on $\bar{K}$ and f of S

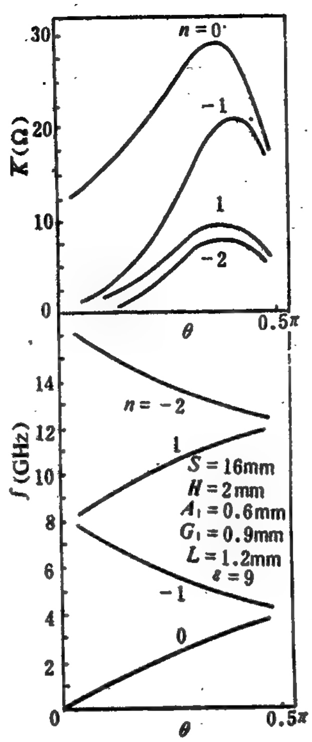
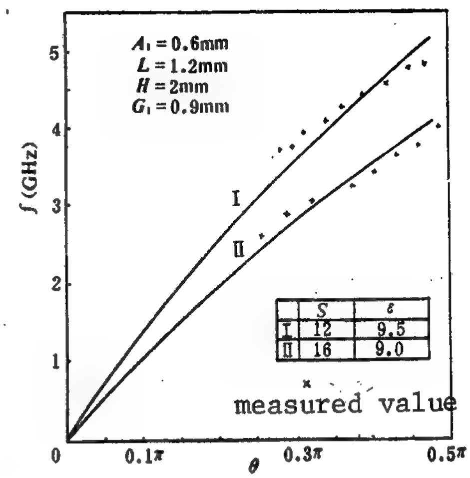


Figure 8
High order spectral wave characteristics



	S	ε
I	12	9.5
II	16	9.0

Figure 9
Comparison of computed and measured values of dispersion characteristics

Figure 8 shows the computational results of the space harmonic characteristics, giving the characteristic curves when n=0, −1, 1, and 2. From the figure it can be seen that the −1 (back wave) coupling impedance is rather high and in design, it is very important to adopt measures to avoid causing back wave oscillation.

Figure 9 is a comparison of the computed and experimental values of dispersion characteristics. The test results and theoretical results of two-group structure conform fairly well. The comparison of the measured value and the gain value of the TWT designed using the value of $\bar{K}$ obtained from computations (see Figure 10) demonstrates that the computed value of the coupling impedance can serve as a reference point for engineering design.

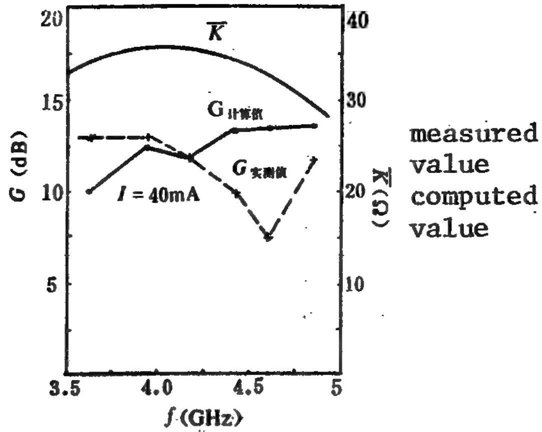


Figure 10. Comparison computed and measured gain

VI. Conclusion

Through comparison with experimental values, the method of computing the coupling impedance and dispersion characteristics of microstrip meander-line slow-wave structure shows clearly that it is feasible and that this method can be a reference when solving similar problems. Compared with the methods used in documents [1]-[7], it is more suitable for solving complex boundary problems. This method is also suitable for use in computing microstrip intersecting digital lines.

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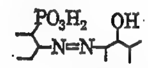
APPLIED SCIENCES

NEW REAGENT FOR PHOTOSPECTROMETRIC DETERMINATION OF THORIUM

Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 6 No 1, 28 Feb 84 pp 43-47

[Article by Pan Jiaomai [3382 2403 7796], Zhou Weiliang [6650 0251 5328], Zhao Hong [6392 3126], and Hu Zhaosheng [5170 2507 5110], Department of Chemistry, East China Normal University, Shanghai: "Chlorophosphonazo-m-SO_3H (CPA-m-SO_3H) as a Reagent for Spectrophotometric Determination of Thorium"; paper received 19 Feb 83]

[Text] Bis-azo derivatives of asymmetric chromotropic acids containing the  analytical functional group are sensitive color reagents for the detection of rare earths. Examples of such compounds include m-hydroxychlorophosphonazo[1], m-acetylchlorophosphonazo[2,3], m-nitrochlorophosphonazo[4], p-nitrochlorophosphonazo[5,7], and m- and p-formychlorophosphonazo[8], and m-chlorophosphonazo sulfonic acid (CPA-m-SO_3H)[9], which have been used for rare-earth mass assays and for photometric detection of yttrium and rare-earth elements in the cerium family. We have investigated further how reagents of this type react with thorium, uranium, and cerium and have found that at low pH CPA-m-SO_3H reacts sensitively with thorium but much less sensitively with uranium and cerium; the new reagent CPA-m-SO_3H thus provides a method for photometric determination of thorium which is selective and highly sensitive.

I. Principal Reagents and Instruments

The reagents were:

1. Standard thorium solution: Starting with a suitable amount of analytical-grade thorium nitrate we prepared a roughly 1 mg/ml thorium solution which we standardized with EDTA in dimethylphenol orange. This solution was diluted to 10 µg/ml for use in the experiments.

2. The standard uranium solution was prepared from analytical-grade uranium acyl nitrate. A precise amount of this uranium solution was then carefully measured, evaporated to dryness, and roasted in an 800-1000°C over until the weight stabilized; the concentration of the uranium solution was expressed in terms of the weight of Ur_3O_8. This solution was diluted to 10 µg/ml for use in the experiments.

3. The standard rare-earth solution was prepared by carefully measuring a precise amount of the spectrally pure rare-earth oxide and dissolving it in 6 M HCl (the cerium oxide was dissolved in concentrated sulfuric acid and hydrogen peroxide). The solution was heated and evaporated to dryness, dissolved in 1 : 100 HCl, and diluted to the desired concentration. The solution was then standardized with EDTA with dimethylphenol orange as indicator. The solution was diluted to 10 μg/ml for use in the experiments.

4. The chlorophosphonazo reagent was prepared as follows. Except for CPA-m-SO_3H, which was prepared by the method described in this paper, the other chlorophosphonazo derivatives were prepared by the techniques reported in [2-5, 8] and purified by the method introduced in [10]. We used 0.02 percent and 0.01 percent solutions in our work.

Instruments:

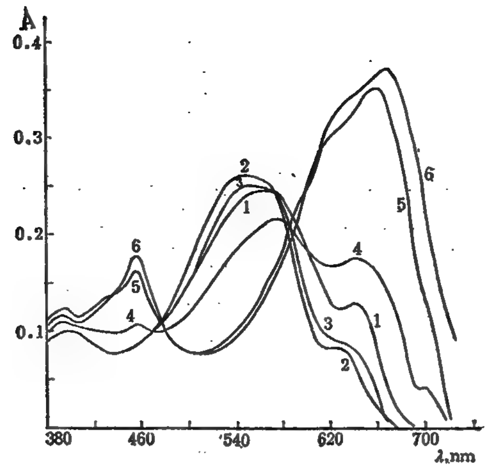
1. Model 808 Hitachi double-beam spectrophotometer; model 751 spectrophotometer.

2. Model RT-11 microcomputer.

II. Synthesis of CPA-m-SO_3H

We placed 1 g of m-aminophenyl sulfuric acid (0.058 M) in 5 ml of water, added 0.5 g of Na_2CO_3 to promote solution, and cooled the solution to 0°C. We then added 0.5 g of sodium nitrite, 8 ml of concentrated HCl (using a pipette; the temperature was held between 0 and 5°C), and cooled the solution to 0°C. We then slowly added a small amount of urea to eliminate bubbles from the solution and set it aside in a refrigerator for future use.

We also dissolved 2 g of chlorophosphonazo I (0.0037 M) in 15 ml of hydroxylated uranium solution (LiOH : H_2O = 1 : 9), cooled the solution to 0°C, added the same sodium nitrite (diazonium salt) solution described above (holding T between 0 and 5°C), and used the LiOH solution to adjust the pH to 9 - 10. After one half of the diazonium solution had been added, it was necessary to use paper chromatography to determine the endpoint of the titration (we used a 5 : 2 by volume mixture of 5 percent sodium citrate and 25 percent aqueous ammonia as the developer; the spots on the paper were blue in color but the spots corresponding to chlorophosphonazo I were red; the endpoint was reached when the red spots became fainter and disappeared). The addition of the diazonium salt was then terminated and the reaction product allowed to sit overnight. The next day we added 10 ml of concentrated HCl and let the solution sit for a day; we then filtered it and washed the filtrate with a small amount of 6 M HCl. About 1.5 g of product was recovered after desiccation in an 80°C oven.



[R] = 5.28×10^{-6} M

Fig. 1 Absorption Curve for CPA-m-SO_3H Recorded by the Hitachi Model 808 Photometer with 1-cm-long Measurement Cells

Key:

1. pH = 6.2
2. pH = 1.0
3. [HCl] = 1.92 M
4. [HCl] = 4.8 M
5. [H_2SO_4] = 5.76 M
6. [H_2SO_4] = 14.4 M

The product, a brown powder, was highly soluble in water and remained stable for long periods of time.

III. Electronic Spectrum of the CPA-m-SO_3H Molecule

1. Absorption Spectrum

Figure 1 shows the experimentally recorded absorption spectra of CPA-m-SO_3H for several pHs.

The main absorption peaks occur at the following wavelengths:

pH 6.2, peaks at 640, 565, and 402 nm;

pH 1, peaks at 545 and 399.5 nm;

for [HCl] = 1.92 M, peaks at 548 and 400 nm;

for [HCl] = 4.8 M, peaks at 640, 573, 455, and 394 nm;

for [H_2SO_4] = 5.76 M, peaks at 658, 456, and 390 nm;

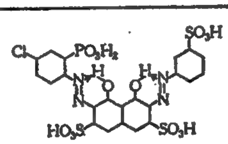
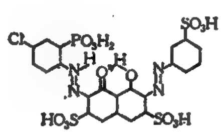
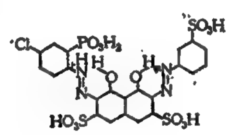
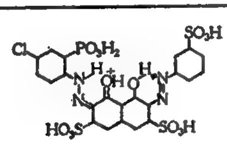
for [H_2SO_4] = 14.4 M, peaks at 670, 458, and 396 nm.

2. Quantum Chemical Calculations

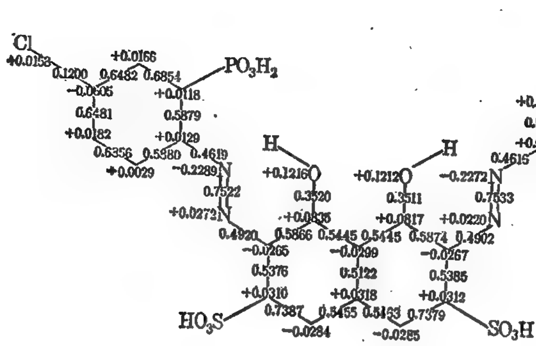
We used the OSHMO program on the RT-11 microcomputer to carry out the quantum chemical calculations in order to determine the preferred structure of CPA-m-SO_3H in aqueous solution, gain further insight into the relationship between the structure and function of color reagents, and accumulate relevant theoretical data for improving and developing new organic color reagents. Table 1 presents the calculated peak absorption wavelengths for four possible molecular configurations.

The wavelengths of the peaks in the electron absorption spectrum were calculated from the differences in the molecular orbital energies for CPA-m-SO_3H. Structure I is evidently preferred under acidic conditions (pH 1) since the calculated peaks for this structure agree most closely with the experimental data. However, in strongly acidic solution ($[H_2SO_4]$ = 14.4 M) structures III and IV are present, with III predominating.

Table 1. Calculated and Experimental Peaks in the Electron Absorption Spectrum for CPA-m-SO_3H

Reagent	Molecular structure	Calculated, nm		Experimental, nm	Medium
I		LUMO HOMO	544.5	545	pH 1 酸性溶液 (acidic)
		NLUMO NHOMO	399	399.5	
II		LUMO HOMO	616		
		NLUMO NHOMO	303		
III		LUMO HOMO	677	670	$[H_2SO_4]$ 14.4*M* 强酸性溶液 (strongly acidic)
		NLUMO NHOMO	460	458	
IV		LUMO HOMO	610	396	
		NLUMO NHOMO	429		

The results of the quantum chemical calculations can also be used to draw a molecular diagram for CPA-m-SO_3H showing the distribution of the net electronic charge density for each atom and the bond lengths and angles between neighboring atoms. The diagram for structure I is given by



IV. Color Reactions of U(VI) and Cerium With CPA Reagents

1. Procedure

We put 10 μg of cerium (or U(VI)) in a 25 ml bottle to which we successively added 5 ml of 6 M HCl and 5 ml of ethanol in order to increase the solubility of some of the color reagents (this enabled us to avoid analyzing precipitates or the color changes in the reagents themselves). We then diluted 3 ml of the 0.02 percent CPA reagent with water to the calibrated volume, and agitated the solution uniformly. We then placed the solution inside the 1-cm-long measurement cell of the Model 751 spectrophotometer. Using the corresponding reagent as the reference blank, we then recorded the wavelengths of the absorption peaks for each of the sample complexes.

2. Results and Discussion

The measurements are shown in Table 2, which yields the following conclusions:

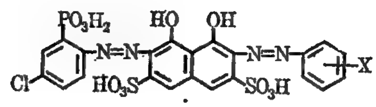
(1) In all cases the nonsymmetric CPA reagents react more sensitively with thorium than do the CPA III reagents with the symmetric type-III structure. This difference is particularly pronounced for CPA-m-SO_3H.

(2) We find that the sensitivity of the color reaction of nonsymmetric CPA reagents with uranium is lower in all cases except for CPA-m-Cl (ôther conditions in the comparison remaining the same).

(3) Except for CPA-m-SO_3H there is a clear increase in the sensitivity with which the nonsymmetric CPA reagents react with cerium.

(4) A comprehensive examination of the reactivities of the reagents with thorium, uranium, and cerium indicates that CPA-m-SO_3H may be well suited for thorium assays.

Table 2. Color Reactions of Chlorophosphonazo (CPA) Reagents With Thorium, Uranium, and Cerium



试 剂①	Th			Ce			U(VI)		
	λ_{max}	$\Delta\lambda$②	A(ε)③	λ_{max}	$\Delta\lambda$②	A(ε)③	λ_{max}	$\Delta\lambda$②	A(ε)③
CPA III	690	145	0.098(5.7×10^4)	665	120	0.099(3.5×10^4)	670	125	0.106(6.3×10^4)
CPA-p-CH_3	690	135	0.143(8.29×10^4)	675	120	0.181(6.3×10^4)			0.005④
CPA-m-SO_3H	670	120	0.174(1.01×10^5)			0.026④			0.005④
CPA-p-CHO	685	130	0.151(8.76×10^4)	675	120	0.275(9.6×10^4)			0.000④
CPA-m-$COCH_3$	675	120	0.160(9.28×10^4)	665	110	0.290(1.0×10^5)			0.032④
CPA-m-COOH	675	120	0.162(9.40×10^4)	665	110	0.305(1.1×10^5)			0.004④
CPA-m-NO_2	675	125	0.153(8.87×10^4)	665	115	0.275(9.6×10^4)			0.000④
CPA-p-NO_2	680	130	0.137(7.95×10^4)	670	120	0.270(9.5×10^4)			0.000④
CPA-m-Cl	675	125	0.134(7.77×10^4)	670	120	0.270(9.5×10^4)	690	140	0.169(1.0×10^5)

Key:

1. m-X and p-X denote meta and para substituents
2. The shift $\Delta\lambda$ is equal to the difference between the wavelengths of the experimental absorption peaks for the complex and for the reagent
3. The numbers in parentheses give the molar absorptivities
4. These values are the absorptivities measures at maximum absorption of the reagent and thorium--reagent complexes.

V. Use of CPA-m-SO_3H for Photometric Determination of Thorium

1. Experimental Procedure

We added 8 ml of 6 M HCl and 3 ml of the 0.01 percent CPA-m-SO_3H solution to 10 µg of thorium in a 25 ml bottle and diluted the solution with water to the specified volume. The mixture was then agitated and the absorption analyzed near 670 nm in the 2-cm-long measurement cells of the Model 751 spectrophotometer.

2. Results and Discussion

(1) Absorption Spectrum of the Complex

The experiments revealed that the peak absorption of the complex occurs at 670 nm (cf. Fig. 2).

(2) Analysis of Complex Formation

We used continuous concentration variation method and the equilibrium shift method to study thorium-reagent complexation in a 1.92 M HCl medium. The experiments revealed that the thorium : reagent molar ratio in the complex was equal to 1 : 2 (cf. Figs. 3, 4).

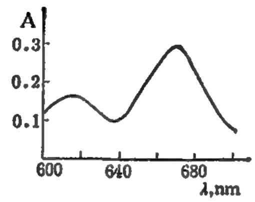


Fig. 2 Absorption Curv for the Thorium Complex

$[Th] + 1.7 \times 10^{-6}$ M
$[R] = 1.8 \times 10^{-5}$ M
$[HCl] = 1.92$ M

(3) Effects of Acidity on the Color Reaction

$CPA\text{-}m\text{-}SO_3H$ can form stable complexes with thorium for a wide range of acidities, cf. Fig. 5. In view of the selectivity of the reaction, we used 8 ml of 6 M HCl in all of the experiments.

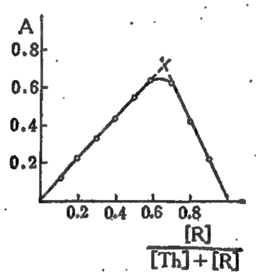


Fig. 3 Molar Ratio of the Complex, Measured by Job's Continuous Variation Method

$[Th] + [R] = 5.28 \times 10^{-6}$ M

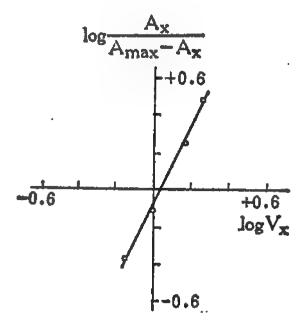


Fig. 4 Molar Ratio of Complex Measured by the Equilibrium Shift Method

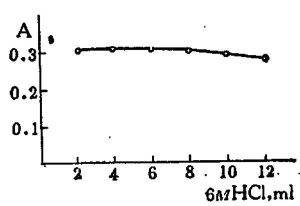


Fig. 5 Effect of Acidity

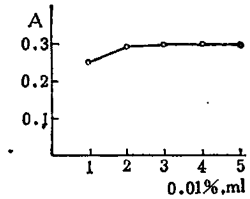


Fig. 6 Absorption vs volume of color reagent added

(4) Influence of the Amount of Color Reagent Added

According to our experiments, the addition of 3 ml of 0.01 percent color reagent suffices to saturate the thorium absorption curve, cf. Fig. 6.

(5) We experimentally investigated how the color reaction was altered by the addition of oxalic acid. The results indicate that there is little effect (Figure 7), so that any convenient amount of oxalic acid may be used as a masking agent.

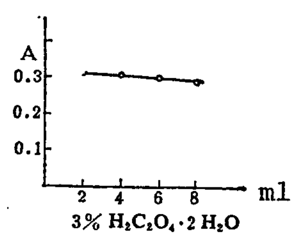


Fig. 7 Absorption vs Volume of Oxalic Acid added

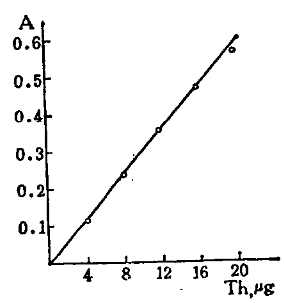


Fig. 8 Calibration Curve

(6) Stability

The color reaction is complete and instantaneous, and the absorption of the complex remains virtually constant for at least 2 h.

(7) Calibration Curve

Under the conditions specified above, Beer's law is obeyed for thorium concentrations between 0 and 16 μg/25 ml (cf. Fig. 8).

(8) Interference From Extraneous Ions

Table 3 shows the experimental results found for extraneous ions using the procedure described above. The table implies that milligram amounts of most extreneous ions do not interfere with the measurements. The addition of 0.3 mg of yttrium or ytterbium, 0.2 mg of zirconium, 0.1 mg of uranium, or 0.1 mg of lanthanum or cerium has no influence on the measurements when oxalic acid is present.

Table 3. Effect of Extraneous Ions Present in 10 µg of Thorium

Ion	Amount added (mg)	Amount of thorium measured (mg)	Ion	Amount added (mg)	Amount of thorium measured (mg)
Zn^{2+}	10.0	10.0	Bi^{3+}	5.0	10.4
Ti^{4+}	0.3	10.2	Sb^{3+}	2.0*	10.7
Mn^{2+}	10.0	10.1	Sn^{4+}	2.0*	10.4
Fe^{3+}	1.0	10.4	U(VI)	0.1	10.8
Ba^{2+}	5.0	10.1	Ce^{3+}	0.05	10.5
Mg^{2+}	10.0	10.1		0.1*	10.9
Ca^{2+}	5.0	10.2	La^{3+}	0.07	10.7
Pb^{2+}	10.0	10.0		0.1*	10.6
W(VI)	5.0	10.0	Y^{3+}	0.3	10.6
Mo(VI)	3.0	10.5	Yb^{3+}	0.3	10.2
Co^{2+}	5.0	10.0		1.0*	10.9
Cr^{3+}	2.0	10.2	$P_2O_7^{4-}$	2.0	9.8
Ni^{2+}	5.0	10.6	F^-	2.0	10.0
Cu^{2+}	2.0	10.5	SiO_3^{2-}	25.0	9.9
Al^{3+}	10.0*	10.4	SO_4^{2-}	10.0	10.0
Zr^{4+}	0.2	10.4	PO_4^{3-}	100.0	9.6

*) 5 ml of $H_2C_2O_4 \cdot 2H_2O$ was also added.

VI. Conclusions

1. We studied the reaction of nine chlorophosphonazo reagents with thorium, uranium, and cerium under highly acidic conditions. Nonsymmetric CPA reagents react more sensitively with thorium than does the symmetric type-III CPA structure under identical reaction conditions; this is particularly true for CPA-m-SO_3H, which is highly selective. Under our conditions (1.92 M HCl medium) the addition of milligram amounts of extraneous ions does not interfere with the measurements; the measurement results are also unaffected if somewhat smaller amounts of rare earths (U(VI), or circonium are added.

2. We carried out a quantum chemical calculation of the electron spectrum for the CPA-m-SO_3H molecule and deduced the net charge densities and bond parameters.

References

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APPLIED SCIENCES

A SPECTROPHOTOMETRIC METHOD FOR DETERMINATION OF TRACE AMOUNTS OF URANIUM

Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 6 No 1, 28 Feb 84 pp 48-51

[Article*by Xue Guang [5641 0342] of PLA Unit 00524: "On the Color Reaction of Polycomponent Complex--System of u-5-Br-PADAP-Sulfosalicylic Acid-Cetylpyridinium Bromide"]

[Text] This article discusses the properties and synthesis of the complex U(VI)--5-Br-PADAP-sulfosalicylic acid-cetylpyridinium bromide (CPB), and a spectrophotometric method is developed for detecting micro-amounts of uranium in ores. The method is quick and simple and has good sensitivity and selectivity.

Experimental Part

I. Instruments and Reagents

Model 72 spectrophotometer (Shanghai Analytical Instrument Plant)
0.05 percent solution of 5-Br-PADAP in ethanol
1.5 percent solution of cetylpyridinium bromide (CPB) in ethanol
2.5 percent solution of cyclohexane diamine tetraacetate (CyDTA)

The latter solution was prepared by adding 25 g of CyDTA to 700 ml of water, adjusting the pH to 8 by adding 40 percent sodium hydroxide, and then diluting with water to 1 liter.

1 percent aqueous solution of sulfosalicylic acid

The triethanolamine buffer solution was prepared as follows: 74.5 g of triethanolamine was dissolved in 350 ml of water, adjusted to pH 8 with 1 : 1 HCl, and diluted to 500 ml with water.

The standard uranium solution (1 mg uranium in 1 ml of solution) was used to prepare standard uranium solutions of various concentrations.

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* Paper received 23 Nov 81.

Ammonium fluoride, ammonium nitrate, ammonium chloride, and ammonium sulfate salts were then mixed in a 3:1:1:0.5 ratio by weight and the product was dried and ground.

II. Experimental Method

A precise amount of the standard uranium solution was placed in a 25 ml bottle to which we successively added 10 ml of water, 1 ml of 2.5 percent CyDTA, and 1 ml of 1 percent sulfosalicylic acid. Using phenolphthalein as an indicator we made the solution red by adding 1 N sodium hydroxide and then extinguished the red color by titrating the solution with 1 N HCl. We then added 2 ml of the triethanolamine buffer, 1 ml of 1.5 percent CPB, and 1 ml of 0.05 percent 5-Br-PADAP and diluted the resulting solution with water to the calibrated volume. The solution was uniformly shaken, and its absorption was then measured relative to a reference blank inside a 3-cm-long colorimetric cell (wavelength 595 nm).

Results and Discussion

I. Experimental Conditions

1. Absorption Curves

Figure 1 shows that the sensitivity of the binary U^{VI} + 5-Br-PADAP complex in acetone (curve 2) is quite low, and there is no well-defined absorption peak. If CPB and sulfosalicylic acid are added separately to the binary complex, there is some increase in the sensitivity of the corresponding ternary complexes U^{VI} + 5-Br-PADAP-CPB and U^{VI} + Br-PADAP-sulfosalicylic acid (curves 3, 4). This indicates that CPB and sulfosalicylic acid both participate in complexation. If CPB is added to the U^{VI}-5-Br-PADAP-sulfosalicylic acid complex, the sensitivity of the resulting quaternary complex is found to be higher (curve 5). According to curve 5 the absorption of this quaternary complex peaks at 595 nm; the corresponding molar absorptivity is 8.8×10^{-4} ml/(cm.mole). The peak is shifted by 16 nm toward longer wavelengths compared to the peak for the ternary U^{VI}-5-Br-PADAP-sulfosalicylic acid complex.

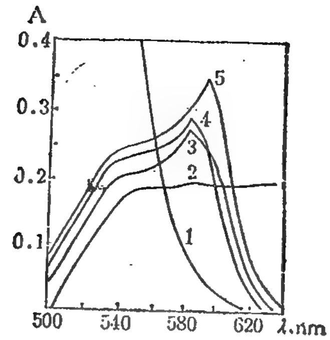


Figure 1. Absorption Curves

Key:

1. 5-Br-PADAP-sulfosalicylic acid-CPB relative to water blank
2. U^{VI}-5-Br-PADAP (acetone medium), relative to reference blank
3. U^{VI}-5-Br-PADAP-CPB relative to reference blank
4. U^{VI}-5-Br-PADAP-sulfosalicylic acid (in acetone), relative to reference blank
5. U^{VI}-5-Br-PADAP-sulfosalicylic acid-CPB relative to reference blank

2. Effect of Acidity

The experiments revealed that the absorption of the quaternary complex peaks within the pH range 5.5∼9.0; pH = 8 was selected for the experiments.

3. Influence of the Amounts of Added Reagents

The experiments demonstrated that the absorptivity of a 10 μg U^{VI} sample is not affected if less than 5 ml of 2.5 percent CyDTA is added; 1 ml was added in the experiments.

The sulfosalicylic acid participated in the complexation. When more than 0.25 ml of 1 percent sulfosalicylic acid was added, the absorptivity saturated at its maximum and remained constant. In the experiments we added 1 ml of sulfosalicylic acid.

The addition of CPB increases the micelle concentration and produces micellar complexes which dissolve readily in water. The experiments revealed that as the amount of 1 percent CPB added increased beyond 1 ml, the absorption peaked and then became constant. We added 1.5 ml of CPB in the experiments.

The addition of 0.5 ml of 0.05 percent 5-Br-PADAP solution is sufficient to completely color a 10 μg sample of U^{VI} (we added 1 ml).

We used 2 ml of the triethanolamine buffer at pH 8 (the results were independent of the specific amount of buffer chosen).

4. Stability of the Complex

The experiments revealed that the quaternary U^{VI}-5-Br-PADAP-sulfosalicylic acid-CPB complex rapidly becomes colored, and the absorption rises instantaneously to its maximum value. The absorption remains essentially constant if the complex is allowed to stand for 15 h.

5. Calibration Curves

We see from Figure 2 that Beer's law is obeyed by a 25 ml solution containing from 0 to 20 μg of U^{VI}. More than 95 percent of the U^{VI} is recovered by extraction chromatography.

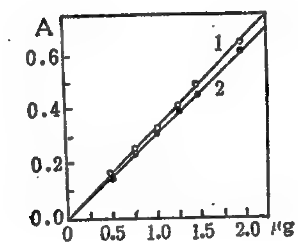


Figure 2. Calibration Curve

Key:

1. Direct colorimetric curve
2. Curve recorded after chromatographic extraction

6. Influence of Extraneous Ion Impurities

In accordance with the experimental procedure described above, we carried out chromatographic measurements on 10 μg of U^{VI}. The results showed that for 25 ml of color reagent, the permissible amounts of impurity ions are as follows (the numbers in parentheses give amounts in μg): Th^{4+}(4.0), Zr^{4+}(2.0), Ce^{3+}(3.0), La^{3+}(2.0), Y_2O_3(1.0), Yb_2O_3(1.5), Fe^{3+}(3.0), Cr^{6+}(4.0), V^{5+}(0.02), Mo^{6+}(7.0), Ti^{4+}(0.03), Ca^{2+}(2.0), Al^{3+}(1.0), Cu^{2+}(0.5), W^{6+}(1.0), Mn^{2+}(4.0), Mg^{2+}(2.0), Nb_2O_5(0.5), Ta_2O_5(0.1), SO_4^{2-}(1000.0), NO_3^-(1000.0), PO_4^{3-}(4.0), F^-(187.5), ascorbic acid (300.0). The V^{5+} and Ti^{4+} ions interfere relatively strongly but can be eliminated by extraction chromatography with TBP-polytrifluorochloroethylene.

II. Complex Formation

We employed the equimolar continuous variation, equimolar ratio, and slope ratio methods to analyze the formation of the quaternary U^{VI}-5-Br-PADAP-sulfosalicylic acid-CPB complex. The experimental results indicate that U and 5-Br-PADAP are present in the complex in a 1:1 ratio (Figs. 3-6), while the ratio of U to sulfosalicylic acid is 1:2 (Fig. 7) and that of U to CPB is 1:8 (Figs. 8, 9). Thus the composition ratio of the U^{VI}-5-Br-PADAP-sulfosalicylic acid-CPB complex is 1:1:2:8.

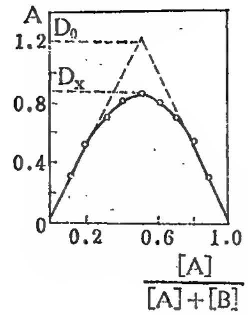


Fig. 3 U^{VI}/5-Br-PADAP molar ratio measured by the equimolar continuous variation method, [U] + [5-Br-PADAP] = 1.0 x 10^{-3} M (here and below, sulfosalicylic acid and CPB were present in excess)

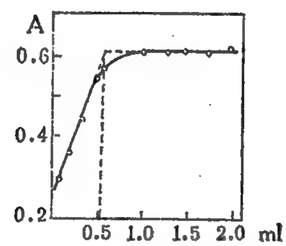


Fig. 4 U^{VI}/5-Br-PADAP molar ratio measured by the equimolar ratio method (the concentration of U^{VI} in the initial solution was fixed at 1.0 x 10^{-5} M and a 5.0 x 10^{-4} M solution of 5-Br-PADAP was added)

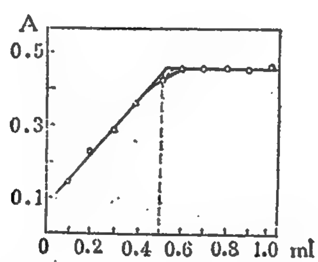


Fig. 5 U^{VI}/5-Br-PADAP molar ratio found by the equimolar ratio method (the concentration of the initial 5-Br-PADAP solution was fixed at 1.0 x 10^{-5} M and 5.0 x 10^{-4} M of U^{VI} solution was added).

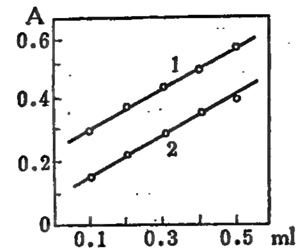


Fig. 6 U^{VI}/5-Br-PADAP molar ratio found by the slope ratio method.

Key:

1. 5.0 x 10^{-4} M 5-Br-PADAP solution added to the initial 1.0 x 10^{-5} M U^{VI} solution
2. 5.0 x 10^{-4} M U^{VI} solution added to a 1.0 x 10^{-5} M solution of 5-Br-PADAP

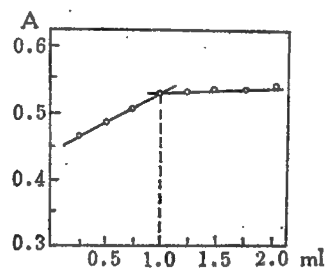


Fig. 7 U^{VI}/sulfosalicylic acid molar ratio determined by the slope ratio method (a 5.0 x 10^{-4} M solution of sulfosalicylic acid was added to a 1.0 x 10^{-5} M solution of U^{VI}). 5-Br-PADAP and CPB present in excess

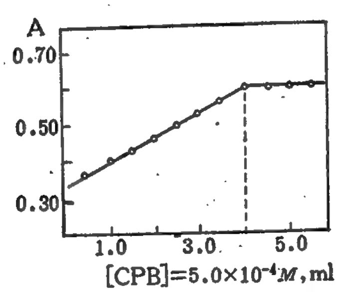


Fig. 8 U^{VI}/CPB molar ratio from the slope ratio method (a 5.0 x 10^{-4} M solution of CPB was added to a 1.0 x 10^{-5} solution of U^{VI}). Here and in the subsequent figure, 5-Br-PADAP and sulfosalicylic acid were present in excess

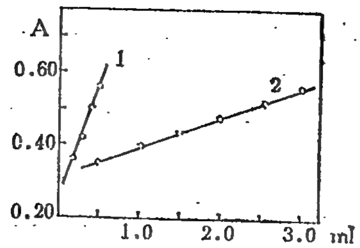


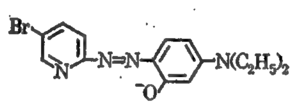
Fig. 9 U^{VI}/CPB molar ratio from the slope ratio method

Key:

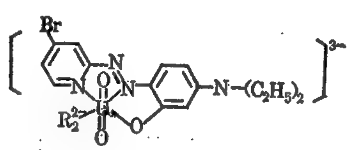
1. 5.0×10^{-4} M of U^{VI} solution added to 1.0×10^{-4} M CPB solution
2. 5.0×10^{-4} M of CPB solution added to 1.0×10^{-5} U^{VI} solution

III. Investigation of the Properties of the Charged Cluster in the Complex

In order to study the charge properties of the quatenary complex we conducted the following experiment. The colored U^{VI}-5-Br-PADAP-sulfosalicylic acid and U^{VI}-5-Br-PADAP-sulfosalicylic acid-CPB solutions were chromatographed in the standard way using 201 x 7 and 001 x 7 anion-exchange resin columns, respectively, and we observed the ion-exchange behavior. The colored ternary and quaternary solutions were adsorbed on the respective columns; the ternary complex was found to be a complex cation with mixed ligands, while the quaternary complex which formed in the presence of CPB was a positively charged micelle complex. Under the experimental conditions (pH 8), 5-Br-PADAP exists in the form[1]



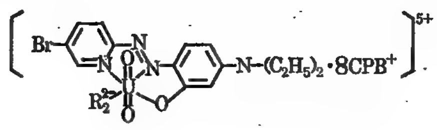
The 1:1:2 molar ratio of the ternary complex suggests the structure



where R denotes sulfosalicylic acid.

When surface-active CPB cations are present, the properties of the U^{VI}-5-Br-PADAP-sulfosalicylic acid ternary complex change radically. According to the theory of charged micelles, at concentrations above the CMC threshold CPB forms micellar particles which act as a positively charged organic solvent. In the quaternary complex system these positively charged particles are electrostatically attracted to the ternary anionic complexes, and quaternary complexes are formed.

The CPB can be regarded as an external ligand which is inserted into the outer boundary of the ternary complex. The 1:1:2:8 molar ratio of the components of the quaternary complex suggests the possible structure



IV. Sample Analysis

We weighed out 0.5 - 1.0 g of sample (of constant apparent uranium content) and placed it in a long, narrow 100 ml beaker; we then added 5-7 g of the mixed ammonia salts and melted the mixture on a hot plate under low heat until the white vapor was almost completely driven off and collected. We then added 5 ml of aqua regia, and the mixture was allowed to evaporate until nearly dry. The complex extracted chromatographically using 10 ml of 1:2 nitric acid at a rate of 1.5 ml/min (the column was first equilibrated with the 1:2 nitric acid). The impurities were washed away by treating the filtered sample successively with 10 ml of 1:2 nitric acid and 8 ml of 1:1 hydrochloric acid. The chromatographic column was drip-washed with 3 ml of water and discarded. We then added 10 ml of water to the sample and analyzed it for uranium in a 25 ml bottle. Table 1 summarizes the analytical results obtained by the experimental procedure described above.

Table 1 shows that our method is quite accurate and precise. According to the analytical results for mineral sample No 807004*), the smallest detectable amount of uranium calculated by the method in [2] is equal to 1.3×10^{-7} g, which is equivalent to 0.13 of the microgram of uranium per gram of sample.

* The measurements were made in 10 ml of color-indicator solution.

Table 1. Results of Ore Analysis

No.	Sample No.	previous result, g/g	Our values (g/g) Individual measurements	Average value	Difference, g/g	Standard deviation	Fluctuation parameter
1	761	7.8×10^{-6}	7.4×10^{-6}		-4.0×10^{-7}		
2	762	1.30×10^{-5}	1.26×10^{-5}		-4.0×10^{-7}		
3	763	6.8×10^{-6}	6.2×10^{-6}		-6.0×10^{-7}		
4	801	1.10×10^{-5}	1.18×10^{-5}		$+8.0 \times 10^{-7}$		
5	802	1.97×10^{-5}	1.95×10^{-5}		-2.0×10^{-7}		
6	803	9.8×10^{-6}	9.5×10^{-6}		-3.0×10^{-7}		
7	807012	1.7×10^{-6}	1.8×10^{-6}, 1.5×10^{-6}	1.7×10^{-6}	0		
8	807016	2.4×10^{-6}	2.7×10^{-6}, 3.0×10^{-6}	2.9×10^{-6}	$+5.0 \times 10^{-7}$		
9	16282	3.6×10^{-6}	3.4×10^{-6}		-2.0×10^{-7}		
10	16279	1.0×10^{-6}	9.4×10^{-7}		-6.0×10^{-8}		
11	Ej 178-80	7.88×10^{-4}	7.86×10^{-4}		-2.0×10^{-6}		
12	Ej 183-80	5.36×10^{-4}	5.45×10^{-4}		$+9.0 \times 10^{-6}$		
13	Ej 177-80	2.85×10^{-4}	2.88×10^{-4}, 2.88×10^{-4}, 2.85×10^{-4}, 2.88×10^{-4}, 2.85×10^{-4}, 2.90×10^{-4}, 2.85×10^{-4}, 2.88×10^{-4}, 2.89×10^{-4}	2.88×10^{-4}	3.0×10^{-6}	2.0×10^{-6}	0.70
14	807004	3.1×10^{-7}	3.8×10^{-7}, 4.1×10^{-7}, 3.7×10^{-7}, 3.7×10^{-7}, 3.6×10^{-7}, 3.8×10^{-7}, 3.9×10^{-7}, 4.0×10^{-7}, 4.1×10^{-7}, 3.6×10^{-7}	3.8×10^{-7}	7.0×10^{-8}	3.4×10^{-8}	9.0

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APPLIED SCIENCES

CHINESE LANGUAGE INPUT VIA COMPUTER KEYBOARD

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21, No 7, Jul 84 pp 37-43

[Article by Xu Jialiang [6079 1367 4731], Tianjin Institute of Technology]

[Text] Abstract: The article investigates the status in Chinese language data processing by various methods of keyboard input of Chinese language material to computer. These methods are summarized and classified, and the characteristics of different methods of keyboard input are compared. The problem of coding abiguity is analyzed from a mathematical viewpoint, and the restrictions between reducing code ambiguity and increasing code efficiency is examined. It is suggested that user and operator convenience be the main basic criterion for judging system suitability. Some limitations in research on Chinese language keyboard input are also analyzed, and methods for overcoming them are suggested. Several new schemes for Chinese language keyboards are introduced at the end of the article.

The Chinese language consists of two components, spoken words and written characters, and computer processing of Chinese language material can certainly not be based simply on a character-by-character analysis. Whether we use the spoken or the written language to communicate with computers (that is, whether the syllable or the written character is the basic unit), the input will necessarily be governed by the grammatical relations among words. In order to automate Chinese language processing, we must address the computer and interact with it in Chinese rather than adhere rigidly to input and output in the form of printed Chinese characters. Consequently, this paper discusses the more general problem of keyboard input of Chinese language material to computers, as opposed to keyboard input of Chinese characters alone.

I. Chinese Data Processing and Keyboard Input

Computer processing of Chinese language material involves inputting the data, storing it, processing it, transmitting it, and outputting the results. The input stage is the first step in this process. We will discuss several methods of Chinese language input (some of which are still in the experimental stage) as follows:

Chinese language input method

- keyboard input
- input by character stroke
  - traditional Chinese calligraphic style
    - brush stroke character keyboard
    - display screen capable of accepting brush stroke
  - printed style
- input via intelligent terminal (keyboards, light pens, and related screen displays)
- input using pattern recognition
  - acoustic recognition
  - geometric character recognition
    - printing-press characters
    - hand-written characters

The most desirable and convenient method would naturally be to have the computer directly "recognize" human speech or written characters. However, a great deal of painstaking work will be required before this ideal form of input is a reality. Progress here will be contingent upon breakthroughs in electronics, acoustics, optics, and many other areas of technology, as well as on further progress and development in pattern recognition and machine intelligence. In short, one cannot expect that practical methods permitting computers to recognize spoken Chinese words and written characters will become available in the foreseeable future, and in the meantime some (less ideal) method is urgently needed.

The keyboard used to input Chinese text to computers should be as inexpensive and simple to develop as possible, and a single keyboard should be able to handle all of the computer encoding requirements. Interest in these problems has been increasing, and keyboard input of Chinese material is currently the most basic and important method.

In the future, manual entry via keyboard will not become obsolete even if computers capable of recognizing speech and written characters become commercially available. This is due only in part to the cost-effectiveness of keyboard input for users with modest performance requirements; the main reason why keyboards will not become obsolete is that they are already indispensable for man-machine communication in numerous intelligent machines capable of pattern recognition. This situation may be likened to what is happening in the industrially developed nations, where plant automation and precision machine tools have not eliminated the need for such traditional tasks as manual sawing and filing.

Research on Chinese language keyboards will thus yield results which will continue to be useful in the future.

II. Keyboard Input and Character Encoding

English was the basic language used in developing the early computers, and most keyboards have keys for the 26 letters in the English alphabet, the 10 Arabic

numerals, and a few other commonly used symbols. Many countries have adopted modified phonetic Latin alphabets; textual material in these languages consists of a series of symbols strung together, and input simply amounts to feeding the strips in from the keyboard.

On the other hand, Chinese characters are two-dimensional geometric figures, and some form of geometric character analysis is essential if ordinary computer keyboards are to be used to input Chinese language material. For this reason, one must first specify the correspondence and relationships among each part of the geometric characters and word symbols to be analyzed and determine the structural rules for constructing strings of symbols. The Chinese characters can be represented as strings in accordance with their phonetic characteristics. In this case, additional rules are necessary to resolve the ambiguities caused by homonyms. Of course, it is also possible to combine the phonetic and geometric characteristics in the string-forming process; work along these lines is referred to as Chinese character encoding.

Almost all of the Chinese research on character encoding has been initiated informally be hobbyists, and even today many researchers remain hampered by the lack of opportunity for full-time formal research. Statistics indicate that more than 400 encoding schemes have been proposed in China, of which more than 200 had been formally registered by the end of 1982 (more than 70 of these have been completely worked out and are ready for use).

Although complete information is not yet available, we can attempt to classify the various encoding schemes as shown in the chart as follows:

- Encoding strongly dependent on the phonetic and geometric characterics of the characters
  - use geometric characteristics of characters
    - encode according to stroke pattern
    - encode according to geometric elements (block structure)
    - encode according to local geometric characteristics
    - encode according to total number of strokes
      - arrange in order of stroke sequence
      - arrange in order from top to bottom
      - arrange according to stroke type
      - order according to a quadrilateral or triangular scheme
      - arrange using a tree structure
      - arrange according to total stroke number only
  - use phonetic characteristics
    - use current phonetic representation (pinyin)
    - use pinyin for new characters also
    - encode using both initial consonant and following vowel
      - indicator tone
      - leave out tone
        - use syllable as unit
        - use tone as unit
  - use phonetic, geometric, pitch, and other characteristics
    - encode using shape and sound
    - encode using sound and shape
    - use phonetic, geometric, and semantic information to encode
    - encode in terms of sound and frequency of occurrence
      - use geometric features of character components
      - use phonetic features of character components
- Encoding only weakly dependent on the phonetic and geometric characteristics of the characters
  - assign numerical codes (e.g., four-digit telegraphic codes)
  - input an entire character at a time (code length equal to 1 or 2)

Each encoding scheme has its strong points. In comparing these encoding schemes we will frequently have occasion to compare the encoding efficiencies and ambiguities (i.e., the extent to which different characters can correspond to the same code). These criteria have been endlessly disputed by the originators of the various encoding schemes, so much so that computer developers have been reluctant to risk selecting and testing some of these methods.

High coding efficiency and low code ambiguity are in fact two interrelated but incompatible desiderata and must be considered together.

III. Coding Efficiency and Ambiguity

Regardless of whether the phonetic and/or geometric characteristics are used in the encoding process, one must inevitably cope with the fact that these characteristics are not uniformly distributed in the Chinese lexicon. Moreover, regardless of whether the standard encoding elements are phonetic or geometric, the distribution of Chinese words in any arrangement or classification will also be nonuniform. In essence, the process of encoding Chinese characters (from the first code bit to the last) reduces to a series of successively more refined classifications. The refinement process continues until the Chinese characters within a certain numerical range have been given symbolic well-dispersed code representations, with each Chinese character associated with a string of code elements. We thus see that if we limit the code length and the number of coding elements, there may be many characters which are assigned the same codes (these characters will have certain features in common, and their distribution in the encoding scheme will be localized rather than uniform). In other words, encoding schemes with a specified maximum code length will not be able to handle all of the relevant characteristics needed to distinguish otherwise identical characters. Thus, if the number of coding elements is kept constant, one or more additional code bits will be needed to make these distinctions if ambiguities are to be resolved, and this will inevitably increase the number of encoding bits. If this procedure is adopted there will be less ambiguity, but the code will be more cumbersome for the other characters which were unambiguously encoded to begin with; the added bits are unnecessary for these characters, and the encoding scheme is correspondingly less efficient. Thus coding ambiguity and coding efficiency must both be considered together.

In order to facilitate the analysis, we may as well assume initially that we have an ideal situation in which the code elements for all Chinese characters within a certain numerical range are uniformly distributed at all levels of the classification. We assume that each code contains m code symbols (elements) and is n bits long. We can use simple combinatorial arguments from permutation theory to analyze this situation. The maximum number W of distinct codes for this scheme is given by the equation

$$W = m^n \text{ (where } m > 1\text{, an integer)} \quad (1)$$

Thus if W is specified and m is known, the code length is given by

$$n = \log(mW) = \log(W)/\log(m) \quad (m > 1\text{, an integer}) \quad (2)$$

Of course, the code length n decreases as the number of code symbols m becomes larger. Thus, the code length will be greater if the 10 Arabic numerals rather than the 26 letters in the Latin alphabet are used to encode a fixed number of Chinese characters. As a special case, the code length n becomes equal to 1 if the number of code symbols m is increased so that it becomes equal to the number of Chinese characters to be encoded; this corresponds to having a single key for inputting each entire character. If m is decreased to 1, Eq. (2) becomes meaningless and there is no way to carry out the encoding.

Let us return to the ideal situation considered above, and assume that the i-th code word contains m_i code symbols and that all the code words are of the same length n.

Combinatorial permutation-theoretic arguments then show that the maximum possible number of unique code assignments for Chinese characters is equal to W, where

$$W = \prod_{i=1}^{n} m_i \qquad (3)$$

Of course, Eq. (1) derived above is the special case of Eq. (3) corresponding to $m_1 = m_2 = \ldots = m_n = m$.

We thus see that the number of unique code assignments, the number of code elements, and the coding length are all intrinsically related. A coding scheme cannot excel in terms of one of these criteria without faring poorly with respect to the others. The appropriate compromise between these conflicting requirements depends on the specific application.

In actual fact, except for the whole-character input schemes with one or two keys per character, in all practical situations our above idealization that the code symbols are uniformly represented in the Chinese characters at each stage of the classification is not valid for the encoding of Chinese characters. The truth of the matter is far more complicated. Regardless of the scheme chosen to classify Chinese characters by their sound or geometric form, it is not possible to achieve good encoding using the 10 Arabic numerals or the 26 letters of the Latin alphabet. The number of code elements also varies widely for the different encoding schemes. These complications have obscured the intrinsic relationships between code ambiguity, code efficiency, the number of encoding elements, and the total number of Chinese characters encoded. The actual relation among these criteria cannot be described by simple mathematical formulas like Eqs. (1) - (3). In order to analyze these relationships quantitatively rather than just qualitatively, we are forced to resort to a modern "systems approach." According to this viewpoint, computer processing of Chinese-language material is essentially a problem in "Chinese language/computer systems engineering."

In summary, if the number of coding elements is to be small, one cannot insist that the coding elements be short; similarly, a short code length is not compatible with high coding efficiency, nor will a low frequency of ambiguous code assignments ensure that only a few characters are ambiguously encoded. These criteria for code quality are thus mutually exclusive in the sense that

if one of them is well satisfied, the others will not be. Of course, this is not to say that different encoding schemes cannot be compared; the methods of optimization theory for multiple objective functions can be employed to seek optimal encoding schemes.

Of course, the use of code words of different lengths in practice may be regarded as a method for coping simultaneously with the requirements of coding efficiency and low ambiguity. However, in this case the operators who encode the Chinese language material for input to the computer have no way of knowing in advance whether a given character has the same code assignment as another character (or of knowing how many ambiguous characters there are) and will therefore be unable to decide which detailed encoding method should be used to distinguish the ambiguous characters.

Some of the special rules (including simple codes and abbreviation rules) used to implement schemes with code words of variable length require rote memorization and thereby add to the burden placed on the operators. This procedure shifts the onus of the encoding process to the encoding rules and is thus a poor method from the standpoint of coding convenience.

The frequency of coding ambiguity is often analyzed by considering the codes for Chinese characters which lie within a certain range and calculating the number of ambiguous code assignments (or its logarithm). However, different characters occur with unequal frequency in the Chinese language, and it makes a great deal of difference whether the ambiguous characters are common or infrequent. It is therefore by no means enough to consider the frequency of ambiguous code assignments alone--the probability that more than one character may correspond to the same code must also be considered.

It might thus appear that the above arguments have only succeeded in complicating the problem further. In fact, our problem in "Chinese language/computer systems engineering" is inherently multifaceted and dynamic, and it involves a complicated system. Neither the human operator, the computer, nor the relationships between them must be overlooked in research on Chinese character encoding and keyboard input to computer. These questions will necessarily enter into the analysis when we attempt to find an optimum encoding scheme which strikes a satisfactory compromise among the conflicting objectives.

In assessing and choosing the best schemes we cannot take any single criterion as absolute. For example, in some applications a low degree of code ambiguity can be tolerated. All languages, including Chinese, possess words which sound the same but have different written forms, as well as words which are pronounced differently and have different meanings, yet have the same written form; this phenomenon can itself be regarded as a form of coding ambiguity. However, these ambiguities have never prevented languages from being used over the centuries. Moreover, machine intelligence is fully capable of helping humans cope with small numbers of ambiguous code assignments encountered in Chinese language data processing; we should not overlook the advanced computer techniques which are now readily available and can assist us in our task.

IV. User Requirements and Constraints Which Must Be Imposed on the User

We pointed out above that the various criteria for judging coding schemes for keyboard input are interrelated and impose constraints on one another. It is thus hardly surprising that similar relationships and constraints exist among the components of the entire keyboard input system--the amount of Chinese language data to be input, the keyboard operators, the encoding scheme (including the layout of the keyboard), and the computer hardware (including the central processor and the peripheral devices). Manual (keyboard) input is not possible if any of these components is lacking.

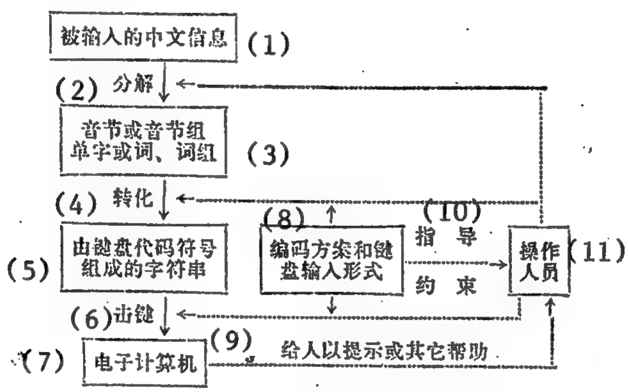


Figure 3.

Key:

1. Chinese language data to be input
2. parsing
3. syllable, syllable group, single character or spoken word
4. translation
5. symbol string made up of keyboard code symbols
6. press key
7. computer
8. type of encoding scheme and keyboard
9. prompt user or supply other forms of assistance
10. guiding constraints imposed on user
11. operators

However, each of the components of the encoding and inputting process shown in Figure 3 is constrained by all of the others and must satisfy certain requirements. For example, the system may constrain the operator in different ways and to varying degrees. For example,

(1) Varying degrees of literacy may be required

- a knowledge of Chinese phonetics (pinyin)
- knowledge of Chinese stroke order, character structure, etc.
- an understanding of the classification and meaning of Chinese character components (basic structural parts and radicals).

(2) The operators may have to be proficient in applying the coding rules (including special rules and short code forms).

(3) The operator may have to translate the Chinese text into code subject to certain speed and accuracy requirements.

(4) If the scheme is based on human translation, a certain degree of manual dexterity (typing speed) may be required.

(5) Coordinated use of eye, ear, and hand may be permitted, or input without looking at the keyboard may be required.

From the standpoint of the user, it would be desirable to relax the literacy requirements; the simpler the coding rules, the better (ideally, no special training would be needed because the encoding scheme would coincide perfectly with normal Chinese writing and speech habits); the input should not strain the memory unduly, and the operators should not be saddled with tiresome code translation, given the availability of advanced computers; the input task should not be too demanding physically--preferably only a small amount of rote memorization will suffice to increase the typing speed (rate of Chinese language input via keyboard), and not too many keys will have to be struck to input a single character. These conditions undoubtedly impose constraints on the hardware and on the encoding scheme (including the arrangement of the keyboard).

If the performance of the hardware is a limiting factor, it is naturally best to minimize the space occupied by each Chinese character in order to permit the input of larger amounts of data. Thus the codes should be short, the ambiguity frequency should be low, not too many code elements (i.e., keyboard keys) should be required, the encoding rules should be simple, and there should be only a few specially defined codes. The constraints which these conditions impose on the encoding scheme are far from trivial.

To summarize, in order to input a specified amount of Chinese language data, the operator, the encoding scheme, and the equipment must jointly share the work load; if the load is eased on one of these three components, the other two must take up the slack. Many aspects of the problem are unclear because human psychological factors are also involved; we must therefore seek ways for quantitatively analyzing systems which are not easy to describe precisely. It is thus necessary to develop a suitable mathematical model, formulate precise optimality criteria, and apply the latest techniques and processing methods in order to distinguish between the different hierarchical and structural levels in the entire system and to coordinate the dynamic relationships between the whole and its parts. System performance should be maximized by ensuring that the capabilities and functions of the components are optimized with regard to the performance of the system as a whole.

Large Chinese data-processing systems contain many different applications systems which are used for different purposes such as communications, publishing, record keeping, retrieval of intelligence information, consulting services, organizational management, translating Chinese and other languages, etc. Because

the optimality criteria will vary with the application, different requirements will be imposed on Chinese data input methods and different technical requirements may be emphasized in the encoding schemes.

Various applications, types of keyboard input, and encoding schemes may be chosen, depending on their suitability in specific applications. Thus, although large keyboards for inputting entire characters are cumbersome and require extensive operator training, they are superior in some respects for electronic photocomposition. Specialists require time to master the system, and the publishing and printing houses must purchase the equipment; however, once this is done people come to appreciate the direct sensory feedback, ease of operation, and the fact that only one or two keys are required per character.

Accuracy and speed are paramount requirements in communication applications. Specialists are often needed to receive and transmit dispatches, and a certain amount of time will necessarily be required for these workers to master a new telegraphic code, which must be memorized and used fluently. The training time required to achieve proficiency may be regarded as of secondary importance--the main thing is that the words be coded efficiently and unambiguously. When computers are used to transmit Chinese language data, the code must be known when the character is input; there is little need for conversion in the other direction, from code to character.

Codes based on character type have advantages for the input of lengthy Chinese texts. For instance, even foreigners unable to read Chinese can copy down the characters and input them to computer according to the type and number of strokes.

Speed can be increased somewhat in applications involving consulting services and retrieval of intelligence information if one relies on specialists to communicate with the computer, and again the time required to train the operators is of secondary importance. However, this type of arrangement becomes inconvenient and uneconomical if many organizations are using the system and a Chinese terminal and one or two operators must be added for each organization. The ideal solution in such cases would be to enable each user to directly access the needed information in the computer with little or no training in the use of the code; at the same time, the man-machine interaction should be as natural and unencumbered as possible from the human perspective. The ability of the computer to "prompt" the user is clearly of great importance here. If the user and computer interact by "conversing" (or if the interaction is of the query and answer type), phonetic input (in pinyin) is more direct than input of characters. Encoding schemes which employ prompting in pinyin have been developed primarily for these kinds of applications.

To summarize, the specific constraints which the application, human ability, and physical resources impose on one another cannot be neglected, and no single optimality criterion should be stressed at the expense of the others. Different features will need to be emphasized depending on the situation.

It is a man who must be the master in the man-machine relationship, not the other way around. As much of the burden as possible should be placed on the

computer instead of on the operator. Most people would undoubtedly prefer that the methods used to improve the coding efficiency and resolve ambiguities require the operator to make as few choices as possible.

Methods for resolving ambiguities:

- develop detailed rules for distinguishing characters with the same code and require that these be memorized by the operator;
- rely on the terminal screen to display characters with the same sound or character code and to prompt the operator to select among them;
- use machine intelligence to select or reject characters with the same code based on analysis of contextual relationships;

Ways of improving code efficiency:

- use short code forms and code words of variable length, which must be memorized and fluently recalled by the operator;
- indicate simple codes on the keyboard (using keypads or overlays);
- use the terminal to display the simple code words, one code being displayed during each step in the entry process, from the first key to the last;
- combine key labels with screen prompting.

Moreover, it is possible (by increasing the load on the computer) to ensure compatibility among the different keyboard input and encoding schemes and thus make it unnecessary in many cases for the operator to remember the multiple codes for each character in the different schemes.

In practice, suitable forms of input must sometimes be developed for computing equipment which has been around for awhile; in other cases, suitable computer equipment is needed to meet the needs of application systems still in the planning stage. The known and unknown variables are interchanged in these two cases, but the relationships among them remain the same.

V. Current Research on Keyboard Input. Limitations and Methods for Overcoming Them

In the previous four sections we have already touched upon some of the factors which have been holding back research on keyboard input. We will discuss some of these here in more detail.

1. There are several encoding schemes, each of which, in the interests of maintaining its own internal structure, advocates the elimination of those

Chinese characters which it is unable to handle, or proposes adding new character strokes or word roots for modifying the forms of certain Chinese characters. The originators of some of the encoding methods favor a status quo as far as reforms of the Chinese writing system are concerned; this will make it unnecessary to alter their codes and lexicons to conform to future changes. On the other hand, others advocate accelerating the pace of writing reform, restricting the use of the written forms, and simplifying the character strokes as far as possible (we note parenthetically that workers in machine pattern recognition believe that such changes may actually make the recognition of the geometric forms more difficult). In addition, coding specialists are perennially arguing about whether phonetic or geometric encoding is best. As long as opinion remains divided it will be difficult to marshall the resources needed to tackle writing reform, and computer specialists will stay on the sidelines, unwilling to risk linking the fate of their machines to acceptance of a particular encoding scheme. Disputes have developed among researchers on which code characters should be used and on whether the 26 letters in the Latin alphabet and the 10 Arabic numerals are sufficient for a keyboard. Problems have also occurred in discussions of Chinese character reform as a matter which can be divorced from reform of the spoken language. For example, only some 1,200 syllables (including tones) occur in normal Chinese speech; since there are some 4,000 Chinese characters in common use, it is hardly surprising that many of them have identical pronunciations. The only result of reducing the number of characters will be to eliminate some of the ideographs; neither the meaning nor the sound which the characters represent can be eliminated. The "one sound, several characters" situation will be replaced by a situation in which one character has multiple meanings and the resulting ambiguities will be just as severe as that associated with homonyms. We must be neither precipitous nor tardy in dealing with the problem of Chinese language reform; research should be based on the present state of the Chinese language as it is currently used in China, yet the long-term objectives of language reform must also be considered.

2. Chinese-language data processing requires complex, multifaceted, dynamic technical solutions. Alternative methods cannot be compared in terms of static criteria alone--a systems approach is necessary. Previous research in this area has been carried out by numerous unrelated individuals using a variety of methods. We should make use of the new approaches provided by modern science and technology and break away from the limitations imposed by traditional methods. Future Chinese work should adopt a systems viewpoint and to eliminate the old-fashioned piecemeal style of research; technical cooperation among the relevant departments and research institutes should be fostered.

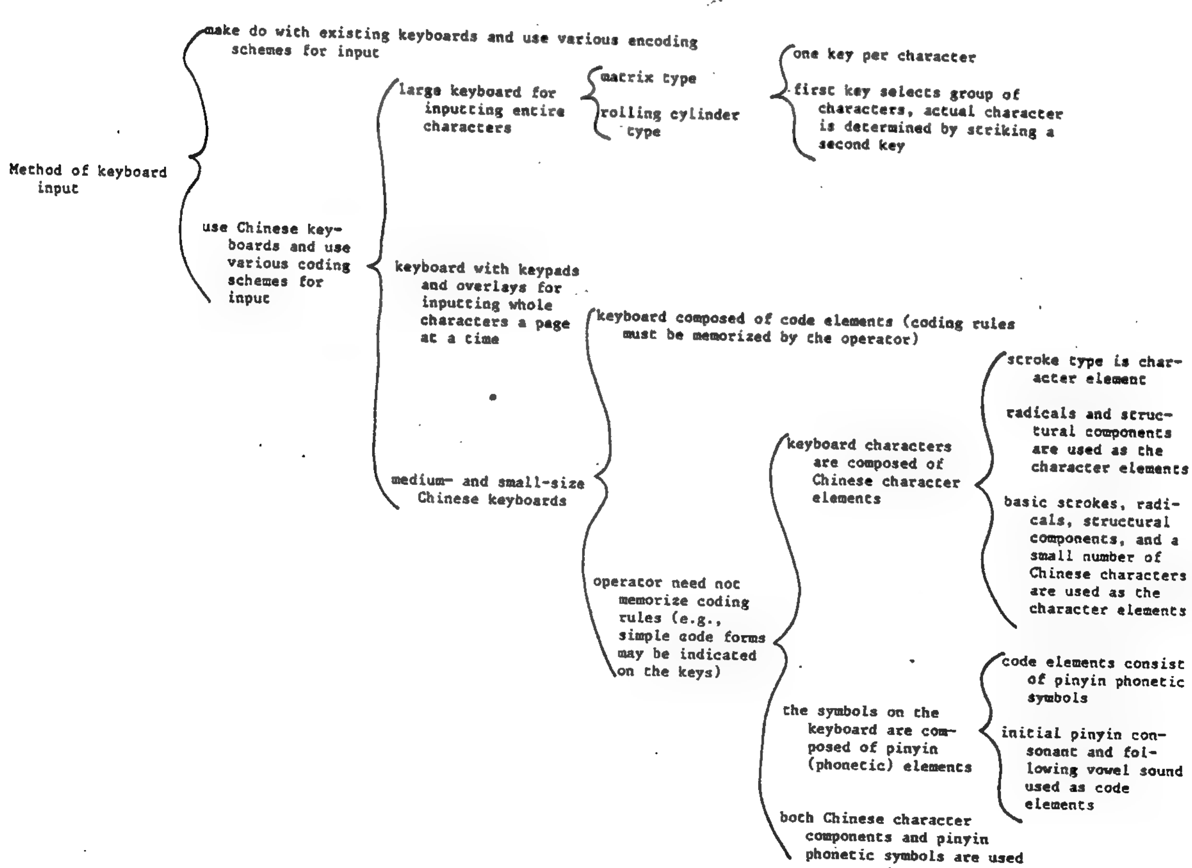
3. The Chinese writing system which we inherited from our ancestors was of course not originally developed with computer applications in mind, nor have existing computers been planned specifically for Chinese-language data processing. The encoding schemes should not impose excessively artificial relationships between the keyboard symbols and the phonetic and geometric characteristics of Chinese characters. It is important not to "cut the foot to fit the shoe" when it comes to research in Chinese-language data processing, which will require special computer systems and suitable keyboards adapted to China's needs.

If we are to solve the problem of Chinese data processing, our modes of thinking and working will have to be suitable for exploiting the capabilities of advanced computers.

VI. Current State and Prospects for Keyboard Input of Chinese-Language Material

Chinese characters are encoded in order to facilitate manual input of Chinese text via keyboards, and the encoding scheme is thus intimately related to the type of keyboard used. Since much of the research on encoding schemes has been done by amateurs, most of whom lack suitable opportunities for testing their codes, the planning and implementation of new keyboards has been held back and most of the encoding has been done using the available computer keyboard symbols as coding elements. A few groups in China have studied specialized large-, medium-, and small-scale keyboards; however, this work has had very little impact on methods of keyboard input in China. Workers involved in code research still do not generally recognize the need and the feasibility of developing "Chinese keyboards" suitable for China's needs, even though the problem is simply one of adapting an applications system to perform a specific task.

We will now summarize the different types of keyboards, of which some are already in existence, some are being built, and some are only in the planning stage.



The ideal solution would be to use compatible schemes to input Chinese words both phonetically and in their ideographic forms. The input operations would then correspond to the standard pinyin or ideographic representations with which the operator is familiar. Assistance through machine intelligence and/or prompting by the terminal screen in doubtful or difficult cases would also be helpful. On the other hand, the specialized equipment should be reasonably compact and should be capable of following the migration of the microcomputer down to the individual end-user. This ideal method of keyboard input should not be too difficult to implement if stronger leadership is provided and closer cooperation is fostered.

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APPLIED SCIENCES

DESIGN AND BUILDING DETAILS OF QINSHAN POWER PLANT PRESENTED

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6, No 6, Dec 85 pp 481-489

[Article by Ouyang Yu [2962 7122 0056]]

[Text] I. Introduction

The Qinshan Nuclear Power Plant is a Chinese-designed and Chinese-built prototype power plant; its rated power output is 300,000 kW. After completion, it will be linked to the East China power grid. It is expected that through the research, design, construction, and operation of this nuclear power plant, China's nuclear industry will benefit in terms of improving its organization, acquiring experience, training personnel, and becoming systematically more proficient in nuclear power technology. Furthermore, it will also facilitate the assimilation of foreign nuclear power technology. Therefore, this project is of paramount importance with regard to both scientific technology and China's economic development.

II. Description of the Plant Location

The power plant is located in Qinshan, Haiyan County, Zhejiang Province; it is 126 km from Shanghai by highway and 92 km from Hangzhou. To the northeast of Qinshan is Hangzhou Bay; the main peak has an elevation of 185.5 m. To the north are low hills which can be flattened so that the main building of the plant will be situated on a rock foundation. To the northwest of the main building is a stretch of beach; a 9-meter-tall, 1,780-meter-long dyke will be constructed in a northwest-southeast direction to enclose 566,000 m^2 of land for auxiliary buildings such as waste solidification treatment plant, air supply, steam supply and cooling facilities as well as spare parts and repair shops. Fangjiashan to the west of Qinshan can be used for future expansion.

The region surrounding the plant has a very stable geological structure; the rock layer where the main plant is located has a slope of 18 percent. The compressive strength of the lock is greater than 10,000 kg/cm^2. The beach area is made of sludge particles and subclay; its load capacity is approximately 8 $tons/m^2$. The hydrological and geological conditions of the terrain near the plant are relatively simple. The base is made of molten rock which has poor permeability. The average temperature in this region is 15.8 C; the historical low temperature recorded is -10.8°C, and the high is 38.1°C. The average rain-

fall is approximately 1,076 mm. The prevailing wind direction is east-southeast; in the summer, typhoons may bring severe storms with wind velocities as high as 32.2 m/sec.

In terms of hydrology, Hangzhou Bay is a semi-enclosed area with typical characteristics of a river outlet. The tides rise and fall twice per day, and the average temperature is 18.1 C. The cooling water for the condenser is taken from the nearby trough along the seashore and the warm water is returned to the bay. Because of the large tidal velocity (3-4 m/sec), the ejected warm water is thoroughly dissipated. Fresh water is taken from the Changshan Canal located 10 km from the plant; there is an ample supply of fresh water because the canal is connected to Tai Hu, and the Grand Canal, and the Huangpu Jiang.

Population distribution. The population distribution and population density within a 50-km radius of the plant are shown in Table 1. As is well known, the East China region is China's most populous region; compared to the surrounding regions, the population density near the plant location is relatively low, particularly within an area 20 km from the plant. For example, the average population density of Zhejiang Province is 376 persons/km^2, which is higher than the average population density in an area 30 km from Qinshan; the average population density of the 11 neighboring counties is 569 persons/km^2, which is higher than the average population density in an area 50 km from Qinshan (500 persons/km^2).

Table 1. Population Distribution and Population Density Within a 50-km Radius of the Qinshan Power Plant

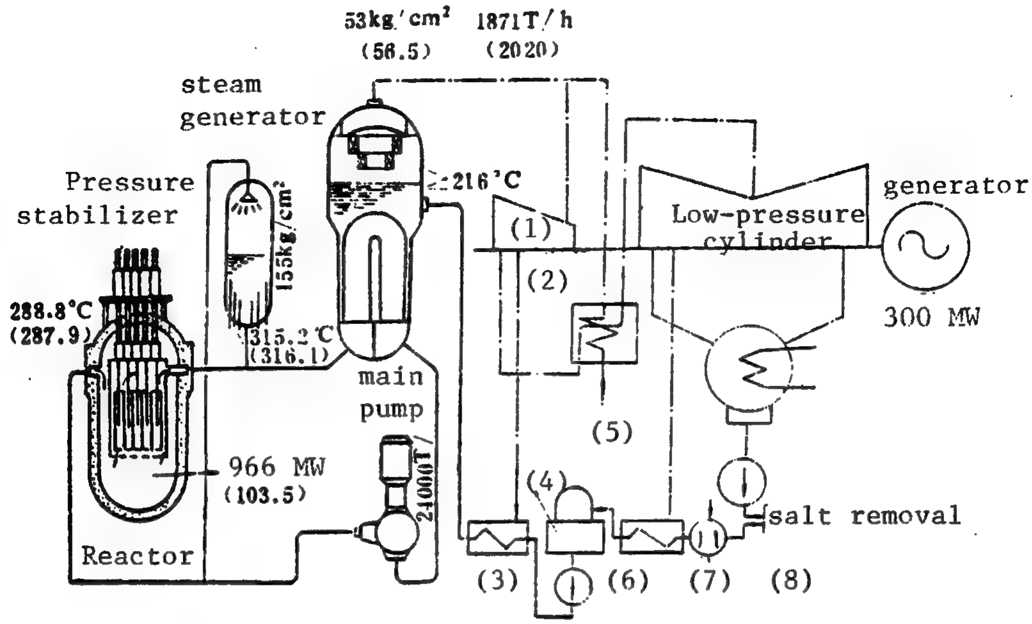
Distance km	4—0.5	0—1	0—2	0—5	0—10	0—15	0—20	0—30	0—40	0—50
Cumulative population	0	287	2816	18725	85994	182381	319335	870327	2070611	3924003
Population density	0	91	224	238	274	258	[illegible]	308	418	500

The power generator of this power plant consists of three major segments: the pressurized water reactor (PWR), the primary circuit system, and the secondary circuit system (Figure 1). The cooling water for the reactor and the primary circuit is under a pressure of 155 kg/cm^2 and has an average temperature of 302 C. The nominal thermal power of the reactor is 966,000 kW at a nominal flow rate of 24,000 tons/hr; it is expected that with sufficient operational experience, it can be increased to 1.035 million kW. The flow rate of steam in the secondary circuit is 1,870-2,020 tons/hr, and the pressure is 53.0-56.5 kg/cm^2. The steam can produce 300,000-330,000 kW of power.

1. Reactor

The reactor unit consists of the reactor core, the reactor interior members, the pressure shell and the control rod drive mechanism (Figure 2). The reactor core is a structure which has 121 fuel elements arranged in a square array with a near-circular cross section. The water-to-uranium ratio in the reactor core (V_{H2O}/V_{NO2}) is 2.0653; the total capacity of NO_2 is 40.744 tons.

Figure 1. Power Generator of the Qinshan Power Plant



Key:

1. high-pressure cylinder
2. steam/water separator and regenerator
3. high-pressure heater
4. oxygen
5. to steam trap
6. water supply pump
7. low-pressure heater
8. air evacuation unit

The first reactor core has three different concentration levels (2.4 percent, 2.672 percent, 3 percent), and the subsequent balanced refueling elements have a concentration level of 3.4 percent. The fuel rods are arranged in a 15x15 square array with 13.3 mm separation between two neighboring rod centers. The shell is made of Zr-4 alloy pipes with 10-mm outside diameter and 0.7 mm wall thickness.

During the design, a series of experiments were conducted to determine the physical, thermodynamic, hydraulic and material characteristics as well as the mechanical properties of the reactor core and the fuel elements in order to verify the reliability of design and to make design improvements based on the test results.

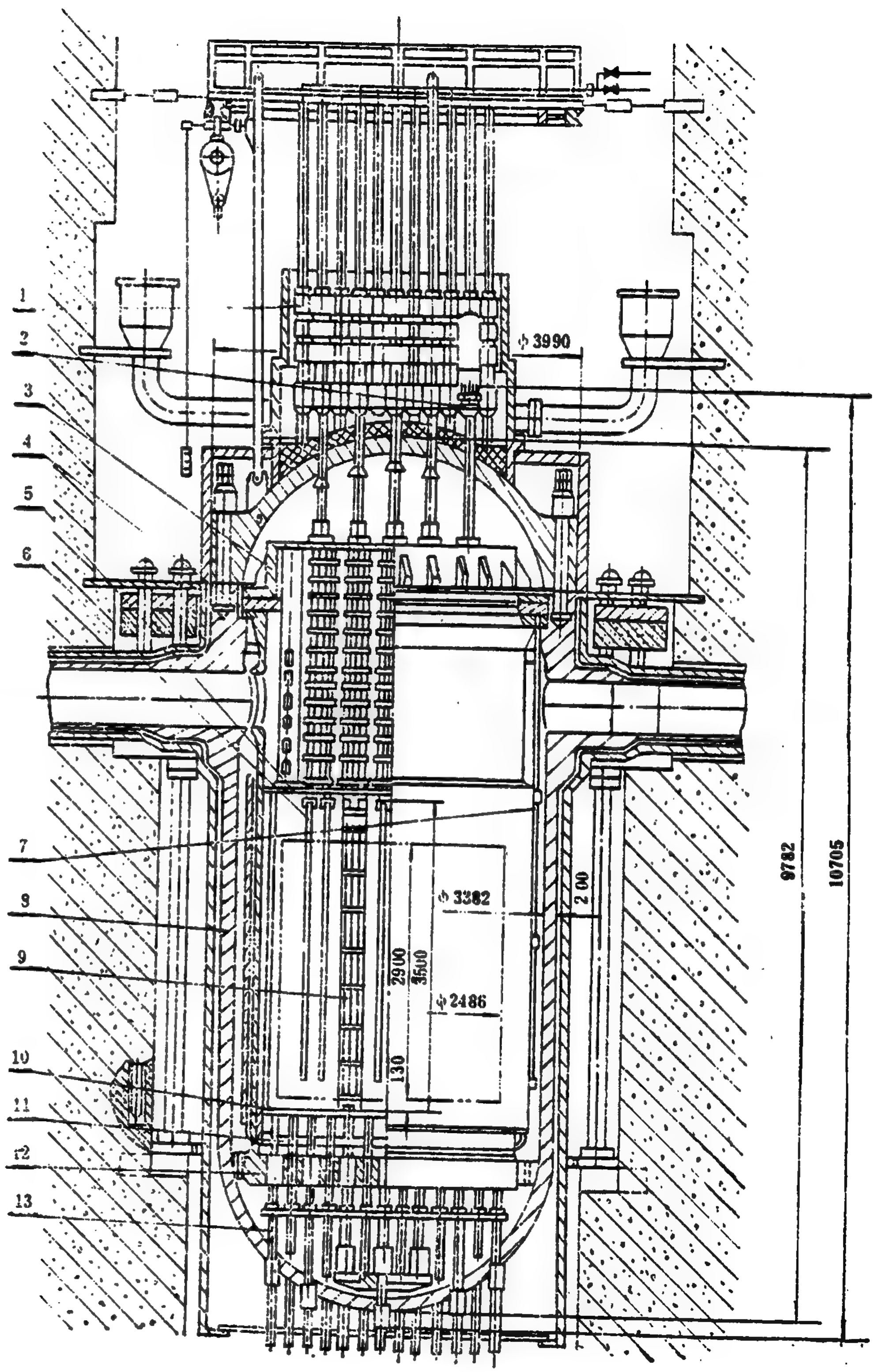
Two different approaches are used in the reactor to control reactivity: the use of bundle type control rods and dissolved boron. The drive mechanism for the control rods is magnetically operated, and has been tested for over 10,000 m continuous travel. Its performance has been demonstrated in terms of wear-resistance, endurance and reliability.

The interior members of the reactor are used to position the reactor core and to guide the coolants through the reactor core; they are also used to guide the 37 bundles of control rods. In addition, 41 thermocouples (for measuring

Figure 2. The Reactor

Key:

1. control rod drive mechanism
2. reactor temperature sensors
3. clamped parts
4. hanging basket
5. upper plate of reactor core
6. control rods
7. radiation monitoring tube for pressure shell material
8. pressure shell
9. fuel elements
10. lower plate of reactor core
11. flow distribution plate
12. bottom plate of hanging basket
13. neutron flux measurement unit inside the reactor



the exit coolant temperatures of the fuel elements), 30 neutron flux measuring tubes and 8 radiation monitoring tubes are installed.

The pressure shell is made of SA-508-III steel, with semi-spherical enclosures on both top and bottom. It is 10.705 m in height, the outside diameter of the cylinder is 3.732 m, and the wall thickness is 175 mm; its design is based on U.S. ASME standards. The pressure shell has two major components: the cover and the cylindrical container, which are joined together with bolts and sealed with two concentric O-rings. The entire shell is made of forged parts to avoid weld lines in the longitudinal direction. In order to minimize embrittlement of the weld lines due to neutron radiation, they are positioned so that direct exposure to the reactor core would be avoided. During the design, stress analysis of the pressure shell was performed using the method of finite elements; also, electric tests and photoelastic tests of a 1:4 scale steel model and a 1:10 scale plastic model were conducted. These analyses and tests showed that the designed pressure shell exceeded the pressure requirements of the ASME-III specifications with ample margin. The pressure shell was manufactured by the Mitsubishi Engineering Co of Japan; Mitsubishi had verified and approved the Chinese design.

2. Primary Circuit System

The primary circuit system consists of two parallel loops. Each loop contains a steam generator and a main coolant pump, which are connected by No 316 stainless steel pipes to the reactor to form a closed circuit. In addition, the system has a pressure stabilizer and pressure relief tank as well as instruments and valves required for operation control and safety.

The steam generator is of vertical inverted U design; its upper section has a 3-stage vapor/water separator. The separator has been tested using moist, hot steam; the separated steam is 99.9 percent free of moisture, which exceeds design requirements.

The main pump is a vertical, single-stage, single-speed mixed type sealed-axle pump. The axle has three mechanical seals; if any stage fails, the remaining stage(s) will still be able to withstand the pressure in the system. The main pump is designed and built by the KSB Pump Factory of West Germany according to our specified parameters and requirements.

The pressure of the primary circuit is regulated by the pressure stabilizer. The electric heater, the atomizer and other equipment of the regulation system have been tested repeatedly for performance and reliability. The top section of the pressure stabilizer is equipped with three electromagnetic pressure relief valves and two safety valves to protect against over pressure.

In addition to the main system, the primary circuit has 16 auxiliary systems. Functionally, they can be divided into the following categories;

(1) Systems to ensure normal operation and porper starting and stopping of the reactor and the primary circuit; they include the chemical volume system, the boron retrieval system, the sealing system of the main pump axle, the water

disposal system, the cooling system for the equipment, the cooling system for removing residual heat after reactor shut-down, and the ventillation system for the workshop.

(2) Systems to protect the reactor and the primary circuit when loss of water occurs, to contain the effects of an accident, and to prevent scattering of radioactivity into the environment; they include the safety injection system, the safety sprinkling system, and the hydrogen removal system.

(3) Systems to retrieve and process radioactive materials to protect the environment; they include the collection, purification and storage systems for waste gas and liquid waste, and the solidification system and processing system for liquid waste and solid waste.

3. Secondary Circuit System

The main component of the secondary circuit is the steam turbine-generator unit. The steam turbine is a single-axle, three-cylinder, four-exhaust condensation type saturated steam turbine. The generator is a dual-water, internally cooled, brushless excitation, three-phase, a.c. generator. Its terminal voltage is 18 kV, and its rotational speed is 3000 rpm.

Between the high-pressure cylinder and the low-pressure cylinder of the steam turbine are two heaters which are designed to remove the moisture and raise the temperature of the steam. When the turbine pressure increases due to sudden loss of load, 70 percent of the steam will be exhausted rapidly into the condenser to avoid excessive shock on the reactor due to the load change. In case of a crack in the main steam pipe, the steam flow rate will be limited by the flow limiter located at the exit of the steam generator in order to minimize the effect of excessive cooling of the reactor due to the loss of steam.

Since the cooling water used in the condenser is sea water, the heat transfer pipes and plates are made of titanium. Also, to ensure the quality of the water supply, the condensation water will be subject to 100 percent salt removal.

IV. Safety Design Measures

Safety has always been the No 1 consideration in the design of this power plant; the first priority is safety, not high performance. In conjunction with preliminary design, preliminary safety analysis and evaluation of environmental effect were also conducted, and accident prevention measures and emergency procedures were established. Safety design measures are generally based on the international standards used in the late 70's. They are also in compliance with the Chinese safety standard "Radiation Protection Regulations."

1. Safety Design Guidelines

The safety design follows the four guidelines described below.

(1) Eliminate possible causes of accident. A good design and superior engineering quality are pre-requisites for ensuring safety. This power plant is equipped with many levels and many different types of safety devices. Sufficient safety margines are provided for critical materials and critical components, and strict quality inspections are conducted to minimize the possibility of accidents.

(2) Prevent conditions of abnormal operations from developing into catastrophic accidents. Multiple levels of independent safety protection and control systems are installed so that when operational parameters exceed their design limits, alarms will be activated and power output will be automatically reduced until the reactor is shut down. Constant monitoring and periodic inspection will be carried out; procedures will be established for safe operation, particularly procedures to prevent abnormal operating conditions from developing into major accidents.

(3) Minimize damages in case of an accident. Accident correction measures are taken for every possible cause of accident in order to prevent radioactive materials from polluting the environment. In addition, effective protective measures must be taken to guard against possible natural disasters such as earthquakes, tides, floods, and typhoons, to ensure that safety-related structures, systems, and equipment will not be damaged and fail to function.

(4) Close monitoring of radiation dosage and radiation protection. Radioactive waste treatment and purification systems, dosage monitoring systems, and protective shields are installed in order to control and ensure that the radiation level released during normal operation and in case of an accident will be lower than the allowable levels specified in the standards 10CFR20 and 10FR100, and in China's Radiation Protection Standards, so that the safety of operating personnel and local residents can be guaranteed.

2. Safety Measures

The following safety measures are taken in the design:

(1) The reactor has negative-response temperature coefficients. In order to maintain good stability during operation of the reactor, and to limit boron concentration in the coolant, burnable poison rods are installed during initial loading of the reactor core, so that the temperature coefficients of the moderator under various operating conditions and all negative. Specifically, these values are as follows:

At initial fuel loading	$\alpha_m^{\circ} = -1\text{x}10^{-5}/^{\circ}\text{C}$
	$\alpha_m^{HFP} = -7\text{x}10^{-5}/^{\circ}\text{C}$
Before first refueling	$\alpha_m^{HFP} = -5.19\text{x}10^{-5}/^{\circ}\text{C}$

(2) Sufficient margin is provided in the thermodynamic design. The calculated coefficient of power non-uniformity of the reactor based on physical zero-power inspection procedure is 2.54; to provide adequate safety margin, the coefficient for thermodynamic design is chosen to be 2.9.

(3) Protective screens are installed to prevent radioactive materials from escaping. Three individual screens are installed for shielding the fuel elements, the pressure shell and the primary circuit, and the safety shell.

(i) Fuel elements. The fuel elements are made of UO_2 core blocks which have high melting point and very stable chemical properties. The total hydrogen content in the core block is limited to less than 2.5 ppm in order to minimize fracture due to hydrogen embrittlement. The mechanical structure of the fuel elements has been tested for mechanical strength, water corrosion, hydraulic surge and hydraulic vibration; it is now undergoing radiation tests.

(ii) Pressure shell and primary circuit. The mechanical design of the pressure shell, the primary circuit and auxiliary systems has adequate safety margin. All metallic surfaces in contact with the coolant are made of austenite stainless steel or high-nickel alloys; the quality of water in the primary and secondary circuits is strictly controlled to minimize corrosion. The structural materials, the weld lines and the reactor weld layers of the components and support members have been subject to non-destructive tests according to ASME Class-I technical standards; they are also subject to periodic inspection during operation in order to discover hidden defects and take timely corrective measures.

(iii) Safety shell. The safety shell is a pre-stressed concrete structure which can withstand the combined load of 1.4 times the peak pressure under loss-of-water conditions plus its own weight, the pre-stress, and the temperature stress. This combined load is supported by several hundred bi-directional pre-stressed steel bars. The entire shell structure has been subject to detailed stress analysis, and conventional steel ribs have been installed based on the analysis results to reinforce the structure, so that the safety factor of structure under pressure loads of an accident is no less than 2.0.

Sealing of the safety shell is accomplished by the steel rib lining on the inner surface. The strength and stability of the steel lining have been carefully analyzed under the pressure load of an accident, temperature pressure, and pre-stress. The several hundred tubes which penetrate the safety shell must also meet very strict sealing requirements. After completion, the safety shell will be subject to strength test and overall leakage test. Under design pressure, the allowable leakage rate is one-one thousandth of the total weight of air inside the safety shell in a 24 hour period. The leakage test will be repeated every few years after the plant begins operation.

(4) Reactor safety protection system. The reactor has 37 bundles of control rods, which can be inserted into the reactor core in 2 seconds under gravity. When the operating parameters exceed their design limits and there is a possibility of endangering the pressure boundaries of the reactor core and the primary circuit, the automatic reactor shut-down signal will cause the control rods to be lowered to provide sufficient depth of thermal shut-down. When shut-down occurs, a signal is generated to stop the steam turbine at the same time.

(5) Special safety measures. In order to prevent reactor core melt-down and to prevent the release of radioactive materials into the environment due to loww of water in the primary circuit or fracture in the main steam pipes. the power plant is equipped with special safety measures which include the following systems:

(i) Safety injection system. The system has four high-pressure safety injection pumps, two low-pressure injection pumps and four safety injection tanks. In case of an accident, the high and low pressure safety injection pumps will inject boron water into the reactor core according to pressure variations in the primary circuit. When the pressure drops to 50 atg, the four safety tanks automatically inject boron water into the reactor core.

(ii) Safety sprinkling system. The system has two safety sprinkling pumps. When the internal pressure of the safety shell rises to 1.5 atg due to loss of water, the sprinkling pumps are activated and boron water containing NaOH is sprayed into the safety pump.

(iii) Safety shell isolation measure. In the case of loss of water in the primary circuit or fracture of the main steam pipes, a safety shell isolation signal is generated in addition to the safety injection signal (isolation of all the conduits except the steam pipes, water supply tubes, and ventillation system conduits). The main steam pipes and water supply tubes are isolated when a special signal indicating fracture of the main steam pipes is generated; the ventillation system conduit of the safety shell is isolated by a signal indicating high radiation level inside the safety shell.

(iv) Hydrogen removal system. The hydrogen removal system is designed to remove the accumulated hydrogen within the safety shell. There are two closed-loop systems each with a hydrogen removal capacity of 150 m^3/hour; each system contains a suction type blower, an air cleaner, and a catalytic hydrogen and oxygen composite remover. In case of an accident, the hydrogen concentration inside the safety shell can be controlled to below 4 percent by activating only one of the two systems.

(v) Safety air purification system. This system includes:

(a) a safety shell air filtering system, which can filter the air in the safety shell once every 4 hours to reduce the radiation level.

(b) safety shell cleaning and ventillation system, which is used for cleaning reactor personnel before entering the safety shell; its air replacement capacity is 1.5 times/hour.

(6) Reliable power supply. To ensure that the power plant will not lose electricity under any circumstances, three independent electric sources are installed for power supply. They include: two independent external sources from different transformer stations of a 220 kW power network. If the two external sources are cut off simultaneously, then the emergency diesel generator unit within the power plant is activated to supply power to the special safety facilities. There are three emergency diesel engines, each with a capacity of 2000 kW.

(7) Anti-earthquake measures. The anti-earthquake design is based on standards for nuclear power plants used by the U.S. and Japan. All structures, equipment and systems of this power plant are designed according to anti-earthquake specifications. Components which are directly related to the safety of the power plant are designated as class-I components.

The earthquake response spectrum of nuclear power plants specified by the U.S. Atomic Energy Commission are used in the design. Specifically, two reference intensities are assumed. One is the operational base earthquake (OBE), which is the maximum earthquake intensity that might be encountered at the plant location over the next 100 years; this value is consistent with the base intensity of scale 6 (AH~.075g) approved by the National Earthquake Bureau. The other value is based on the maximum intensity at the plant location which had been recorded in history and which may be encountered in the future; this intensity plus one defines the safety shut-down earthquake (SSE).

For anti-earthquake and anti-fracture considerations, a 300-ton and a 40-ton pressure dampers are included in the system design.

In addition, specific anti-earthquake requirements are also used in designing various equipment as well as their supports and valves. Special analysis and calculations are performed for Class-I structures, equipment and conduits to eliminate any hidden concerns.

(8) Fire-fighting measures. The fire fighting system of the power plant is designed according to the No. 50-SG-D nuclear power plant fire prevention regulations of the International Atomic Energy Organization and the Chinese "Construction Design Fire Prevention Regulations" TJ16-74; the U.S. NRC Regulatory Guide 1.120 is used as a reference.

Non-combustible construction materials are used. For critical areas such as the control room, the electric cable compartment in the computer room, and the diesel engine room, fire-proof insulation screens are installed to provide fire resistance for more than 3 hours. The control room, the switch room and the transformer room are equipped with fire detection sensors which can automatically activate the alarm; they are also equipped with automatic fire extinguishing systems.

(9) Protective measures against floods, typhoons, and impact of external objects. The effects of tides and typhoons must be given serious consideration. Sea dykes are being built along the shore and will be connected to the existing dykes. The dyke design is based on considerations of high tides that occur once every hundred years and wave heights with corresponding frequencies; the design is verified using once-per-thousand-year high tides plus wave heights with once-per-hundred-year frequencies to ensure safety of the power plant.

In addition, loads due to typhoons, tornados and impact of external objects are also considered in the building design. Analysis results show however that these effects are all smaller than the earthquake loads.

(10) Lessons learned from the Three Mile Island incident. The following measures are taken in arranging the control room.

(i) The control room is arranged according to system functions; instruments for normal operation and emergencies and their respective controls are clearly arranged on the control console and the instrument panel.

(ii) Redundant arrangement is provided for critical instruments so that malfunctioning of one instrument will not lead to incorrect decision.

(iii) For added fire protection, an emergency control room is provided in addition to the main control room.

(iv) Safety-related equipment are located so that the operators can have easy access.

(v) Indicator lights are installed near the controls to attract the attention of operators when abnormalities occur.

(vi) CRT displays are utilized to enhance man-machine interaction, to indicate the status and parameters of malfunctions, and to direct the operators so errors are avoided.

(vii) Technical support centers will be established to provide direction and guidance in case of an accident without interfering with normal operation.

3. Accident Analysis

The accident analysis for this power plant is performed according to specifications of the U.S. standards ANSI-18.2, "Nuclear Safety Design Rules for Fixed Pressurized-Water Reactors."

On the basis of the expected frequency of occurrence and the degree of seriousness, accidents can be divided into three categories: (1) extreme accidents (postulated accidents which are not expected to occur); (2) major accidents (accidents which occur rarely); and (3) general accidents (accidents with medium frequency of occurrence).

To be safe, the accident analyses are carried out by assuming exagerated degree of seriousness and unfavorable conditions, without regard to the actual probability of occurrence of these scenarios. For example, in the case of an accident where fracture of pipes, earthquake, and loss of electricity all take place at the same time so that the reactor must be shut down, it is assumed that a bundle of control rods with the largest reactive value becomes jammed and cannot be inserted into the reactor core. The initial conditions and the physical, thermodynamic parameters are generally chosen to have the most unfavorable values under the particular operating conditions.

During the preliminary design phase, 6 extreme accidents, 7 major accidents and 6 general accidents were analyzed, with emphasis on the extreme accidents and major accidents. The computer programs used in the analyses were developed by the Shanghai Nuclear Engineering Research and Design Institute, with the

exception of the imported RELAP-5 program, which was used for analyzing a loss-of-water accident in the primary circuit. The results of analyses were generally quite satisfactory. For example, a comparison of the analysis results and safety standards for two accident scenarios--dual fracture of the main pipe in the primary circuit and medium, small punctured holes in the pipe--is shown in Table 2. The analysis results for all accident scenarios considered met the specified safety standards.

Table 2. LOCA Accident Analysis Results

Safety standards	Analysis results	
	Dual fracture	Medium and small punctured holes
Maximum fuel rod temp. <1204 C°	= 1098°C	852°C
Zirconium-water reaction <10%	<1%	<1%
Max. thickness of zirconium oxide <17%	≤3.52%	negligible
Reactor core maintaining coolable geometric shape	yes	yes
	L-LOCA	RELAP-5

4. Evaluation of Environmental Effects

The treatment of gas, liquid, and solid waste and environmental protection for the power plant strictly follow the principle of "ALARL." The waste treatment system is generally identical to similar systems used in the U.S. Under normal operating conditions with no leaks in the heat transfer pipes of the steam generator, the concentration in the waste water is 2.05×10^{-9} Ci/L; the annual discharge is only 0.012 Ci (with the exception of tritium). When there is a leakage of 3.17 L/h from the steam generator and 0.5 percent damage to the fuel rods (extreme operating condition), the maximum concentration in the waste water is 2.2×10^{-8} Ci/L, and the annual discharge is 3.65 Ci. The waste water is diluted by the circulating water until the concentration is reduced by three orders of magnitude before it is discharged into the sea.

Similarly, by assuming extreme operating conditions, it is calculated that the effect of discharged waste water on the local residents is to produce a maximum dosage of only 0.03 mrem, the effect of discharged gas is 0.37 mrem, with a total of 0.4 mrem. This value corresponds to only 0.4 percent of the natural background radiation.

In addition, analysis of the radiation levels in the environment from 8 major accidents and extreme accidents showed that they are far below the threshold value given in the U.S. regulations 10CFR20 and 10CFR100. Therefore, the safety of the Qinshan power plant is reasonably assured.

V. Project Development

The development plan of this power plant was reviewed and approved by the late Premier Zhou Enlai in 1974. Since that time, significant amount of research and tests have been conducted, and a plant site has been selected. Of the planned research tasks, approximately 200 have been completed by mid-1982 (at the end of 1984, 220 have been completed), and Qinshan was selected as the site for the power plant. On this basis, preliminary design (including preliminary safety analysis) and manufacturing and procurement of equipment and components were initiated. The preliminary design was completed in October 1983, and was approved by the National Planning Committee in January 1984. Construction design has been underway for over a year, and is still continuing. In June 1983, work began in excavation, field preparation, dyke construction, and the construction of water supply, power supply, and roads; by the end of 1984, they were all completed. In January 1985, construction of the main plant was officially started, and factories in Shanghai, Beijing, Xi'an, and Dalian also began manufacturing of various equipment for the power plant. It is expected that construction will continue for 2 more years through 1986, installation will also take 2 years through 1988; test operation should begin in early 1989. If everything proceeds according to plan, the power plant is expected to begin generating power in the second half of 1989.

The author would like to express his thanks to comrades who are concerned, and who have provided guidance, support and assistance to the Qinshan project.

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SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

SHANGHAI INSTITUTE OF BIOCHEMISTRY DESCRIBED

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[Article by Lin Ruohan [2651 5387 5060]: "The Shanghai Institute of Biochemistry of the Chinese Academy of Sciences"; paper finalized Jan 83]

[Text] The Shanghai Institute of Biochemistry of the Chinese Academy of Sciences was established in 1958. Its forerunner was the Biophysics and Biochemistry Research Institute of the Chinese Academy of Sciences, which was preceded by the pre-Liberation Medical Research Institute Preparatory Office. The Institute of Biophysics and Biochemistry was established in 1950. It undertook basic research in all disciplines and fields in biophysics and biochemistry, and overcame the situation in which biochemical research in China was primarily limited to the study of nutrition. Moreover, it also developed biochemistry as an independent discipline. There were only 20 or so people when it was first established. Feng Depei [7458 1795 1014] was the director and led biophysical research. Wang Yinglai [3769 2019 4202] was the deputy director and led biochemical research. The main problem faced by the biochemistry section before the Institute was established was that China had a weak foundation in biochemical research, limited staffs, and either inappropriate or lacking equipment. For this reason, the main task at that time was to take action to solve these problems. On the one hand, they made great efforts to get Chinese biochemistry workers who were living abroad to return home and participate in the work, and at the same time they relied on their own efforts to adopt various types of measures to train new manpower, such as organizing advanced biochemistry training classes. They trained graduate students and assisted universities in establishing specializations in biochemistry. In the area of scientific research, they firmly grasped the growing points in the development of biochemistry at that time. They developed relatively active research work in such areas as proteins, enzymes, nucleic acid and metabolism. Because the biochemistry part of the Institute of Biophysics and Biochemistry already had a substantial scale and level, the biochemistry section established an independent institute in 1958 with Wang Yinglai as director. There were a total of 80 personnel in the early period after the institute was established, and they continued to carry out research in the areas described above.

Since its establishment, the Institute of Biochemistry has been involved primarily in basic research. As early as the 1960's, molecular chemistry had begun to make itself known within modern biology. In 1964, the State Science Commission entrusted the Institute of Biochemistry with the task of developing research in molecular biology. This played a major role in promoting work in the entire Institute. At that time, the Institute of Biochemistry provided a certain foundation for the development of molecular biology through work on basic and advanced structures of proteins, the biological compounds in proteins, the systemic role of acids, and so on. Based on international development trends and the original foundation of the Institute of Biochemistry, it has been determined that there are three main aspects to molecular biology: (1) the structure of large biological molecules, as well as their functions and compounds; (2) molecular genetics and genetic engineering; and (3) biomembranes. While carrying out systematic basic theoretical research in these areas, we also should be closely tied to reality and actively solve important problems in agriculture, industry, medicine and national defense construction so that we make achievements, provide human resources and make a contribution to the Four Modernizations.

The Institute of Biochemistry achieved 78 major successes in scientific research in the past. Of these, 28 received awards of various types at the Academy, municipal or higher levels (including one first place national natural sciences award and two third place creativity and invention awards. Some of the main successes are:

(1) Artificial synthetic crystalline bovine insulin. This is an important protein with biological activity that China synthesized artificially for the first time in the world. The A-Chain was synthesized by the Beijing University's Chemistry Department and the Chinese Academy of Sciences' Organic Chemistry Institute, while the B-Chain was synthesized by the Institute of Biochemistry. The synthesis of bovine insulin was done by combining the B-Chain and the A-Chain. Work continued on polypeptide synthesis and it has continued to be at the forefront of the world.

(2) Artificial synthetic yeast amino acid transferase ribonucleic acid. The Institute worked hard for 13 years with 5 units in the Academy, and finally completed the artificial synthesis of transfer RNA with a molecular weight of about 26,000 on 19 Nov 1981. Moreover, its chemical structure and biological activity were identical to natural transfer RNA. It standardized the level of synthetic nucleic acid in China, and entered the front ranks of the world.

(3) In research on succinnic acid dehydrogenase, work was completed in 1955 on enzyme separation and purification, and the prosthetic qualities and primary characteristics of the enzyme were also determined. This opened up a route for research on molecular dissocation and recombination and received praise from international colleagues. Later, progress was also made in research on enzyme dynamics.

(4) Research on muscle proteins. Systematic research on the structure of tropomyosin and several of its physiochemical and biological qualities was carried out. This received attention from international circles, and later an important combined investigation on the preservation conditions of the muscles of the Han Dynasty corpse of Ma Wangdui was also carried out.

(5) The effects of luteinizing-hormone releasing factor on the utilization of oxytocin in common fish and synthesis of luteinizing-hormone releasing factor secreted by the hypothalamus and similar materials. Cooperating with brother units, it was successfully used in the catalysis of ovulation and the resolution of problems in the supply of fresh water fry, with obvious economic results.

(6) The asexual reproduction of Hepatitis B-virus (HBV) Subtype adr gene group in bacteria. The significance of this work lies in its being closely integrated with reality in China for the derivation of bacteria carrying Subtype adr gene group hepatitis virus gene groups. This established an excellent foundation for China to independently use genetic engineering measures for the production of A-type hepatitis vaccine.

(7) The utilization of immobilized enzymes in industry. In 1978, the Institute of Biochemistry achieved the first national successes in the use of immobilized enzymes in industrial production. They found that the utilization of immobilized enzymes could lead to continuity in production, and they increased the effectiveness of the enzymes by from several to several tens of times. They received third-place invention awards from the State Science Commission in 1979 for a new technique for producing hexamine base penicillin alkyl acid and a new technique for producing 5-nucleotide.

In recent years, the Institute also has had several important scientific and technical successes: research on the structure and function of insulin and similar materials and on principles of their action, research on plant viruses and mycocorpus, research on the structure and functions of trypsin inhibitors in green beans, research on the replication mechanisms of polyhedron disease toxins in silkworm cytoplasm, measurement of the synthesis of insulin proto C-peptide and radiation immunity, new techniques for using gonadotrophins and high-purity horseradish peroxidase in industrial production, the manufacture of biochemistry instruments such as nucleic acid and protein assayers, enzyme standard measurement testers, micro ultraviolet spectrophotometers, high speed refrigerated centrifuges, platform-style thermostatic oscillators, and other such achievements in basic theoretical and applied research. Some have already been used successfully and are being popularized; moreover, fairly large economic results have been obtained. In the last 2 years, eight types of biochemistry instruments have been transferred to and are being produced in 13 plants in other areas.

The main scientific research tasks over the next 5 years shall include the following areas: (1) The structure of nucleic acid and the transfer, expression, regulation and control of genetic information; (2) molecular

genetics and genetic engineering; (3) the relationship between various levels of protein structures and functions (including enzymes), and protein and polypeptide syntehsis; (4) the structure and function of biomembranes, including glycoprotein, glycolipid, hormone receptors, cell identification, and biological capabilities; (5) research on hormonal and molecular immunology, and so on.

The Institute altogether has eight laboratories and two groups under its direct administration. They are the polypeptide laboratory, the nucleic acid laboratory, the enzyme and biomembrane laboratory, the molecular identification and radiation control laboratory, the steroid hormone laboratory, the protein and virus laboratory, the molecular genetics laboratory, the theoretical biology and instrument technology laboratory, the plant molecular genetics group and the tumor group. In addition, there is also a journal editing office that is responsible for the publication of SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [BIOCHEMISTRY AND BIOPHYSICS]. There also are two subsidiary factories, the Dongfeng Biochemical Reagent Plant and the Subsidiary Number 320 Plant. The Dongfeng Biochemical Reagent Plant can now produce 674 types of biochemical reagents and biochemical medicines, including the many types of tool enzymes and ligase needed in genetic engineering and in the synthesis of nucleic acid. Some of the products are being exported. The Dongfeng Plant has already moved into a new factory building, and the scale can be expanded considerably. Apart from producing common biochemistry instruments and equipment, the Subsidiary Number 320 Plant also can produce super-centrifuges and high speed centrifuges, procedural control instruments and other high precision instruments. There are now a total of 600 personnel (including 117 persons working in the Dongfeng Biochemical Reagent Plant). There are 201 research personnel, including 12 researchers, 23 deputy researchers and 124 research assistants. There are 153 technicians, including 2 advanced engineers, 77 engineers and 39 assistant engineers.

Institute Director Wang Yinglai is a famous Chinese biochemist, and serves concurrently as head of the Shanghai Branch of the Chinese Academy of Sciences. He went abroad to study in England in 1938, and received his doctorate from Cambridge University. He has a broad knowledge of biochemistry, and his research covers a large area, especially in the areas of vitamins, hemoglobin and enzymes, where he has achieved breakthrough successes in research. He has worked arduously for the development of biochemistry in China since liberation, and is one of the most active organizers and primary founders in the development of biochemistry as an independent frontier science. In the area of strengthening relationships between China and other countries in the field of biochemistry, he has done a great deal of work to promote exchanges and friendship with scientists of all countries.

Deputy Director of the Institute, Cao Tianqin [2580 1131 2953], is a famous Chinese protein biochemistry specialist. In his younger years, he studied abroad in England and received his doctorate from Cambridge University. In 1952, he was elected to be the honorary head of the Caius College of Cambridge University. After returning to China, he carried out research

on proteins under the leadership of the Institute of Biochemistry, participated in leading work for the artificial synthesis of insulin, and also made attainments and explorations in research on muscle proteins, plant viruses and other areas.

Apart from achieving several outstanding successes in research work, the Institute of Biochemistry also has had obvious successes in human resources training. From 1979 to the end of 1982, they sent more than 60 middle-level scientific research personnel and graduate students abroad for training. More than 20 of them have completed their studies and returned to China. They now play roles among the backbone or scholarly leadership in all areas of research. Since 1978, they have accepted a total of 72 graduate students, and 25 have already received master's degrees. Through going abroad for training and the acceptance and training of graduate students, the temporary shortage of scientific research personnel is being transformed gradually. Moreover, the Institute also has run several advanced biochemistry training classes and specialized technical training classes, and has systematically passed on the newest specialized knowledge in biochemistry. In the area of international scholarly exchanges, they have entertained more than 600 foreign guests and more than 200 scholarly reports have been presented by foreign guests in the past 6 years. At home, they also have organized two bilateral academic conferences: the PRC-West Germany Conference on Nucleic Acid and Proteins and the PRC-USA Conference on Proteins. Several middle-aged and young scientific research personnel have participated in and presented papers at the conferences.

In addition to being involved in basic research, the Institute of Biochemistry also has paid attention to research on applications and development. It has taken on the responsibility for part of the breakthrough projects and production tasks of the State Science Commission. In research on plant viruses, it has cooperated closely with agricultural units, and has carried out pathogenic identification, and sensitive and rapid serum diagnosis on 30 types of viruses and diseases and more than 10 types of prokaryotic diseases that seriously endanger food and industrial crops. The plant molecular genetics group cooperated in carrying out the insertion of DNA fragments from cotton that was resistant to withering disease into non-resistant varieties and appraised the later generations after the hybridization. In the area of pharmaceuticals, apart from producing some medicines from polypeptide hormones and nucleic acid, they also recently assisted medicine factories to produce simplex insulin and cooperated with hospitals to develop research on hematoporphyrin photosensitivity in cancer diagnosis and on clinical applications of enzyme electrodes. Through strengthened basic research, the Institute of Biochemistry has provided guidance and a theoretical reserve for the development of the biological sciences. At the same time, it also has developed applied and development research that is integrated with national economic construction, and a new situation has appeared with flourishing development in the three types of research work. Currently, under the encouragement of the spirit of the 12th CPC Congress, the S&T personnel of the Institute are now full of confidence, are striving hard, and are making even greater contributions to the early realization of socialist modernization and for the nation and the people.

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